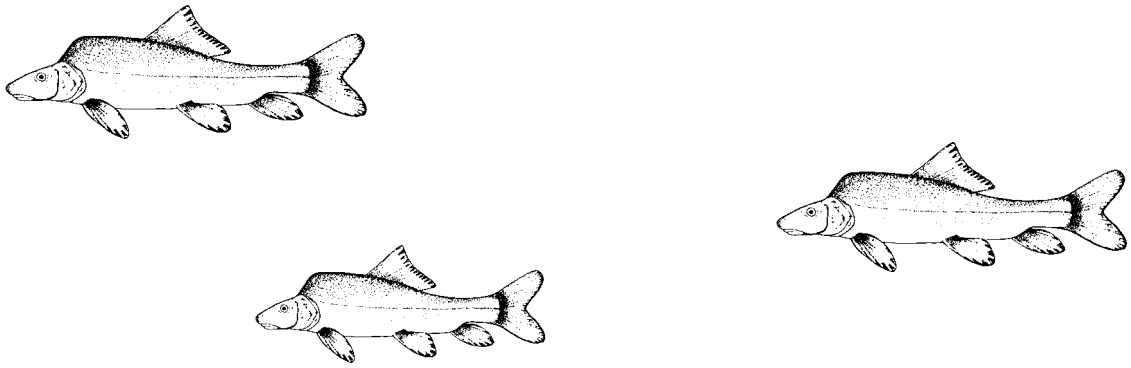
MONITORING OF RAZORBACK SUCKER STOCKED INTO THE SAN JUAN RIVER AS PART OF A FIVE-YEAR AUGMENTATION EFFORT:

2000 Interim Progress Report

(Final)



Submitted By:

Dale W. Ryden

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U.S. Fish and Wildlife Service
Colorado River Fishery Project
764 Horizon Drive, Building B
Grand Junction, Colorado 81506-3946

EXECUTIVE SUMMARY

Razorback sucker (Xyrauchen texanus), is one of two federally-listed endangered fishes found in the San Juan River basin (Colorado pikeminnow, Ptychocheilus lucius being the other). Paucity of collections of wild fish of this species in the late 1980's and early 1990's led to the initiation of an experimental stocking program for this species in 1994. A total of 939 razorback sucker were stocked into the San Juan River as part of that study. Data collected on these experimentally-stocked fish between 1994 and 1997 indicated that a full-scale augmentation effort for razorback sucker in the San Juan River was feasible. In 1997 a FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER was developed. In September of 1997, stocking began with the goal of establishing a population of 15,900 razorback sucker in the San Juan River between Hogback Diversion, NM (RM 158.6) and Lake Powell in UT (RM 0.0).

As of 31 December 2000, a total of 5,208 razorback sucker had been stocked into the San Juan River as part of the five-year augmentation effort. This is a shortfall to date of 50,124 fish. This shortfall is mainly due to the lack of fish available to the San Juan River Recovery Implementation Program (SJRIP). Since the SJRIP had no hatchery or grow-out facilities of its own at the outset of this augmentation effort, razorback sucker had to be obtained from outside sources including the Upper Colorado River Basin Recovery Implementation Program and from Lake Mohave. To remedy the lack of hatchery and rearing facilities and help alleviate the shortfall in numbers of fish being stocked, the SJRIP obtained use of ponds (3 total) at two sites on Navajo Indian Irrigation Project (NIIP) land south of Farmington, NM in 1998 and 1999 and began stocking them with fish obtained from Lake Mohave in the Lower Colorado River Basin (LCRB). The majority of fish stocked into the San Juan River in 1998 (90.3%), and all fish stocked in 2000 were reared in these ponds. In August 1999, one of the ponds, Ojo Pond, washed out due to extremely heavy rainfall. This pond was not rebuilt due to its vulnerable location. In its place the SJRIP built a new pond, Hidden Pond, on NIIP land near Farmington. This pond was stocked with larval razorback sucker for the first time in May 2000. It has become apparent that with the three ponds now in use, the SJRIP cannot produce enough fish to meet the stocking numbers outlined in the 1997 stocking plan. Beginning in 2001, the SJRIP has begun efforts to either build or obtain additional grow-out ponds (totaling 16 surface acres) in order to boost the number of razorback sucker that can be produced and stocked.

To date, 22 (0.4%) of the 5,208 fish stocked as part of the augmentation effort have been recaptured. Three additional razorback sucker that were inadvertently stocked into the San Juan River upstream of PNM Weir (RM 166.6) when Ojo Pond washed out (on 3 August 1999) were recaptured in 2000. Razorback sucker that were stocked as part of the experimental stocking study between 1994 and 1997 also continue to be recaptured. Three razorback sucker that were stocked into Lake Powell in 1995 as part of a separate stocking effort have been recaptured since 1996. An additional six razorback sucker for which no identifying PIT tag number was obtained were also recaptured during the 1997-1999 time period. Other rare fish collected during razorback sucker monitoring trips in May and July 2000 included two stocked juvenile Colorado pikeminnow. No wild roundtail chub (Gila robusta) were collected in 2000.

No habitat use data was collected via radio telemetry in 2000. Razorback sucker were captured at two possible preferred sites in the San Juan River in 2000. One is a suspected spawning area at RM 100.2. The second is centered around a backwater on river left at RM 77.3-77.5. Six razorback sucker stocked into the San Juan River between November 1994 and October 2000 were subsequently recaptured in Lake Powell in between 1995 and 2000.

Several different methods were analyzed to estimate survival of stocked razorback sucker. Using the estimated survival calculations from the 1997 augmentation plan, the estimated number of razorback sucker stocked between 1997 and 1999 and surviving as of 31 December 1999 is about 1,276 fish. This is a shortfall of 14,624 fish from the estimated 15,900 target set forth in the 1997 augmentation plan. However, since these survival curves were, at best, arbitrary when they were developed, population estimates were also performed in 2000 to try to ascertain more closely the size of the razorback sucker population presently in the San Juan River. A Schnabel multiple-census population estimate, for RM 158.6-76.4, placed the razorback sucker in the San Juan River at 152 fish (95% confidence Intervals {C. I.} = 85-309 fish) in May 2000 and 157 fish (95% C. I. = 90-304) in October 2000. An interpolated estimate based on the Schnabel estimate yielded a number of 268 razorback sucker inhabiting the San Juan River from RM 158.6-2.9 in October 2000. A Lincoln-Petersen population estimate performed to verify the Schnabel estimate yielded a number of 135 razorback sucker in the San Juan River from RM 158.6-76.4 in May 2000.

Growth curves based on 108 recaptures showed that total length (TL) of stocked razorback sucker increased the most in the first two years post-stocking, then decreased dramatically over the next several years, with almost no increase in TL being observed by age-8. The greatest observed increase in TL occurred in fish between 261 and 270 mm TL. This size-class fish grew an average 0.22 mm per day. Fish that were small (< 351 mm TL) at time of stocking grew twice as fast (mean = 0.11 mm/day in the river) as did fish that were large (> 350 mm TL) at time of stocking (mean = 0.05 mm/day in river). Fish known to be females were also observed to grow about twice as fast (0.07 mm/day in the river) as did known males (0.04 mm/day in the river).

Although razorback sucker stocked at smaller sizes grew faster than did fish stocked at larger sizes, their recapture (and assumed survival) rates were not nearly as high. Razorback sucker that were > 350 mm TL at time of stocking composed only 616 (10.0%) of the 6,147 total fish stocked in both the experimental stocking study (n = 939 fish) and five-year augmentation effort (n = 5,208 fish). However, they accounted for 71 (79.8%) of the 89 first-time recaptures between 1994 and 2000. Razorback sucker stocked at < 351 mm TL accounted for only 18 (20.2%) of the 89 first-time recaptures, despite composing 5,531 (90.0%) of the 6,147 razorback sucker stocked between 1994 and 2000.

No aggregations of (presumed) spawning razorback sucker (i.e., more than three ripe fish together) were observed in 2000. However, for the third year in a row, University of New Mexico personnel collected what appear to be two larval razorback sucker. One of these presumed larval razorbacks was collected at RM 112.1 (upstream of the presumed spawning site at RM 100.2), while the other was collected downstream near Lake Powell at RM 10.7. If these two larvae are indeed razorback sucker, it would mean that adult razorback sucker are spawning at more than one site in the San Juan River.

Field activities in 2001 will include two razorback sucker monitoring (electrofishing) trips, one in late April or early May and another in mid to late July. In addition, four adult razorback sucker (2 males, 1 female, and 1 of indeterminate sex), implanted with radio transmitters (tags) in October 2000, will be tracked from March through June to attempt to identify spawning behavior and habitats. Up to six adult razorback sucker (> 400 mm TL) collected on the October 2001 main channel adult fish community monitoring trip will be implanted with radio tags for a second year of tracking during spawning season (i.e. spring 2002).

Based on population estimate numbers versus catch per unit effort, sampling efficiency for collecting razorback sucker via electrofishing is usually less than 10%. Sampling efficiency for smaller size-class razorback sucker (< 301 mm TL) is also much lower than for larger razorback sucker. It appears that both survival and sampling efficiency were overestimated when the 1997 stocking plan was developed.

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INTRODUCTION

Razorback sucker (Xyrauchen texanus), is one of three San Juan River native fish species (the Colorado pikeminnow, Ptychocheilus lucius, and the roundtail chub, Gila robusta being the other two) that have become greatly reduced in numbers and range since the turn of the century (Burdick 1992). Physical alterations of riverine habitats, water impoundment in the form of Navajo Reservoir and Lake Powell and their associated effects on flow and thermal regimes, introduction of non-native fish species, and contaminants have probably all contributed to the decline of these native species (Platania 1990, Brooks et al. 1993, Ryden and Pfeifer 1994a). Extremely small numbers of wild razorback sucker and the apparent long-term lack of recruitment led to this fish being listed as endangered under the Endangered Species Act on 22 November 1991 (U.S. Fish and Wildlife Service {USFWS} 1991). The razorback sucker is also currently protected by state laws in Arizona (AZ), California (CA), Colorado (CO), Nevada (NV), Utah (UT), and by the Navajo Nation.

Information on the historic distribution and abundance of the razorback sucker in the San Juan River Basin is sparse. Until the late 1980's the number of fishery surveys conducted in the San Juan River was relatively small compared to the rest of the Colorado River basin (Ryden 2000a). This is probably because much of the San Juan River is canyon-bound in it's lower stretches and a large percentage of the river runs through Indian reservation land (Maddux et al. 1993). Anecdotal accounts of "humpies" from the Animas River near Durango (Jordan 1891), and the San Juan River near Farmington (Koster 1960) indicated the presence of razorback sucker in these areas. However, these accounts were not verified by scientific collections. Pre-impoundment rotenone applications in the Navajo Dam area in 1962 killed fish downriver to Farmington, New Mexico (NM). However, no razorback sucker were documented among the fish killed (Olson 1962). The first scientifically-

documented record of razorback sucker from the San Juan River basin was in 1976 when two adults were seined from a pond near Bluff, UT at about river mile (RM) 81 (VTN Consolidated, Inc. and Museum of Northern Arizona 1978, Platania 1990, Minckley et al. 1991). According to local residents, a second pond adjacent to the one where these two fish were caught was drained just weeks before leaving approximately 100-250 razorback sucker stranded, resulting in their death. These two ponds communicated with the river via a canal that allowed fish movement to and from the river, but only when the headgates were open (VTN Consolidated, Inc. and Museum of Northern Arizona 1978, Platania 1990, Minckley et al. 1991). Between 1987 and 1989 sixteen adult razorback sucker were collected from the San Juan River arm of Lake Powell, in the vicinity of Piute Farms Marina, RM 0.0 (Platania 1990). In 1988 one adult razorback sucker was captured and released in the San Juan River near Bluff, UT, close to the 1976 capture site (Platania 1990). This is the only scientifically-documented collection of a wild razorback sucker from the mainstem San Juan River.

No scientifically-documented, wild razorback sucker have been collected from the San Juan River in either CO or NM. Neither have spawning or recruitment of this species been documented in the San Juan River, prior to 1998. However, the relatively recent presence of a few large adult fish near Bluff, UT suggests that there may have been a remnant population of old razorback sucker remaining in the San Juan River as late as 1988. Extensive electrofishing surveys from 1991 to 1997 failed to collect any wild razorback sucker from the mainstem San Juan River (Ryden and Pfeifer 1993, 1994b, 1995, 1996, Ryden 2000b).

One of the two goals of the San Juan River Recovery Implementation Program (SJRIP) is to protect and recover endangered fishes in the San Juan River Basin, including Colorado pikeminnow and razorback sucker, with the ultimate goal of promoting self-sustaining populations of razorback sucker and

Colorado pikeminnow (SJRIP 1995). This includes reestablishing populations of endangered razorback sucker in appropriate historic habitat, if necessary (Ryden 1997). Due to the paucity of historic and recent collections of this species, including the failure to collect any wild razorback sucker during three years (1991-1993) of intensive studies on all life stages of the San Juan River fish community (Buntjer et al. 1993, 1994, Lashmett 1993, 1994, Ryden and Pfeifer 1993, 1994b, Gido and Propst 1994) the San Juan River Biology Committee identified the necessity to initiate an experimental stocking program for razorback sucker in the San Juan River (Ryden and Pfeifer 1994a). Experimental stocking was implemented to provide needed insight about recovery potential and habitat suitability for the razorback sucker in the San Juan River between Farmington, NM and Lake Powell in UT (i.e., the area designated as Critical Habitat for razorback sucker; Maddux et al. 1993, USFWS 1994).

Between March 1994 and October 1996, 939 razorback sucker were stocked into the San Juan River at four stocking sites (RM 158.6, 136.6, 117.5, and 79.6). Data gathered on these fish identified habitat types being used year-round by razorback sucker in the San Juan River, and provided information on movements, survival, growth rates, and identified a probable spawning site for razorback sucker. Based on the successes of the experimental stocking study, initiating a full-scale augmentation effort for razorback sucker in the San Juan River was deemed to be desirable. In 1997 a FIVE-YEAR AUGMENTATION PLAN FOR RAZORBACK SUCKER IN THE SAN JUAN RIVER was developed (Ryden 1997). This plan identified a target population of 15,900 razorback sucker in the San Juan River between Hogback Diversion (RM 158.6) and Lake Powell (RM 0.0). In order to meet this target population, it was estimated that 73,482 razorback sucker would have to be stocked between 1997 and 2001. To this end, stocking of razorback sucker began in September 1997. This report provides an overview on the stockings of razorback sucker that took place in 2000 and the data

subsequently collected on those fish. Although they are separate efforts, the five-year augmentation effort is an outgrowth of the experimental stocking study. Likewise, this report is a companion document to final report for the 1994-1997 experimental stocking study (Ryden 2000a). In most areas of this report, data from the experimental stocking study (1994-1997) and the five-year augmentation effort (1997-1999) are combined to strengthen data sets. If the reader should wish to read the final report for the experimental study (Ryden 2000a), it can be accessed via the internet at:

http://southwest.fws.gov/sjrip/7-Year%20Research%20Rpts/stockedrzbk.pdf

Objectives

At its inception, the objectives of the five-year augmentation plan for razorback sucker in the San Juan River were as follows:

1) Determine habitat use and needs, site preference, and movement patterns of hatchery-reared razorback sucker in the wild.

2) Determine survival rates and growth rates of hatchery-reared, known-age razorback sucker in the wild.

3) Determine whether hatchery-reared razorback sucker will recruit into the adult population and successfully spawn in the wild.

4) Determine if hatchery-reared razorback sucker can lead researchers to their wild counterparts.

Objective 4 was dropped in 1999, because after eight years of extremely intensive fisheries collections (1991-1998), it was determined that there was no longer a remnant population of razorback sucker residing in the San Juan River, although a few large, old adults may still persist in the river.

Study Area

The study area for monitoring of stocked razorback sucker extends from Hogback Diversion in NM (RM 158.6), downstream to the Lake Powell interface (RM 0.0; Figure 1). For a detailed description of the geomorphic features of this study area, see the SAN JUAN RIVER STUDY AREA DESCRIPTION *in* Ryden 2000a or any of the other 7-year final research reports at the following web site:

http://southwest.fws.gov/sjrip/

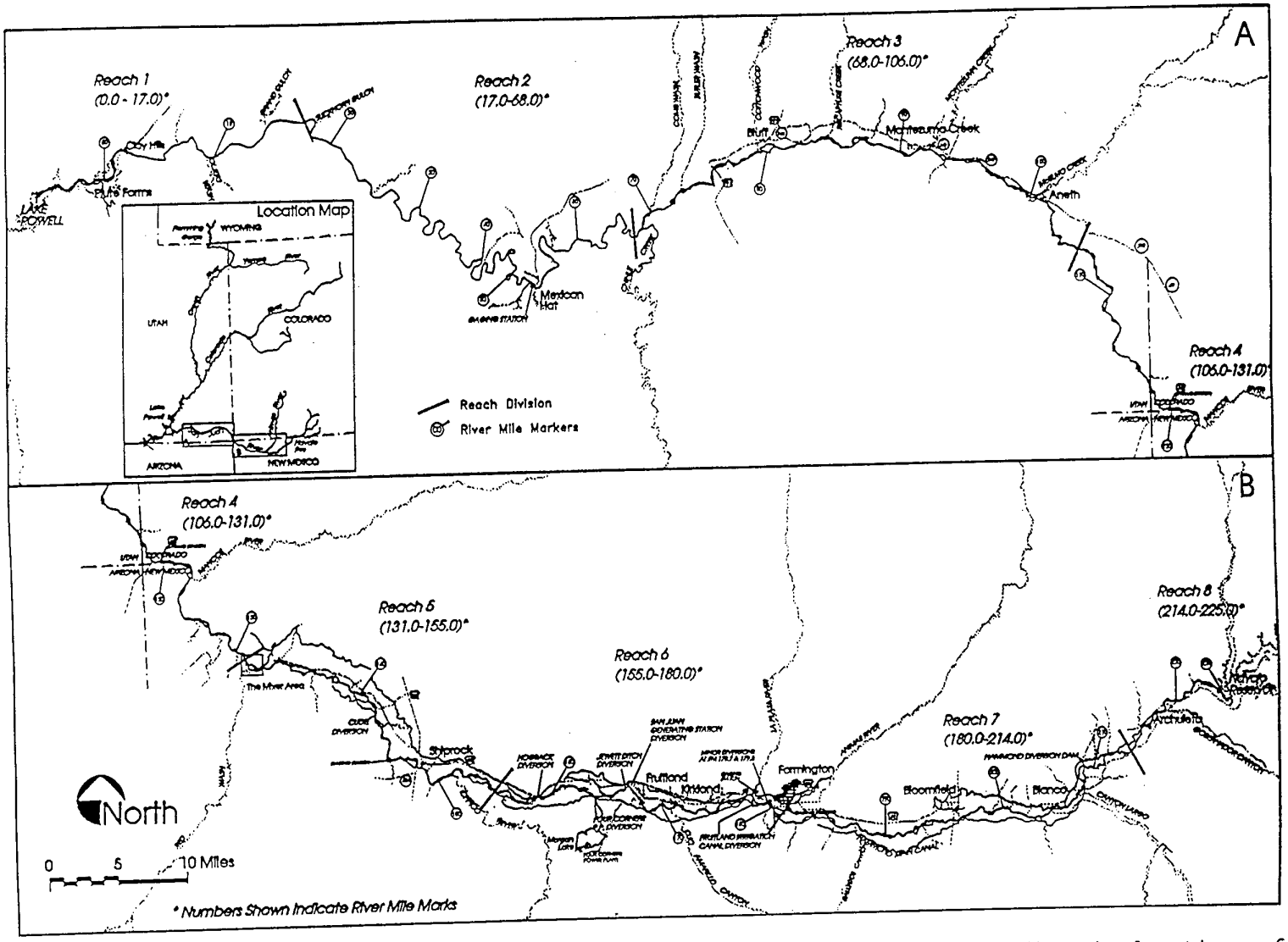


Figure 1. Map of the San Juan River between Lake Powell and Navajo Reservoir, including the locations of major towns, drainages, diversion structures, gaging stations, and river reach designations.

CHAPTER 1: HABITAT USE AND NEEDS, SITE PREFERENCE, AND MOVEMENT PATTERNS

< Objective 1: Determine habitat use and needs, site preference and movement patterns of hatchery-reared razorback sucker in the wild.

METHODS

Stockings of Razorback Sucker

Between 1994 and 2000, 6147 razorback sucker were stocked into the San Juan River as part of either the experimental stocking study (1994-1997) or the five-year augmentation plan (1997-2000). All 939 razorback sucker stocked into the San Juan River between 29 March 1994 and 3 October 1996 as part of the experimental stocking study were F_1 progeny of paired matings between adult razorback sucker that had been collected in the San Juan River arm of Lake Powell (SJRALP) and taken into captivity as broodstock (Table 1). See Ryden 2000a for more details on these fish.

At the beginning of the five-year augmentation plan in 1997, there were no longer any razorback sucker of strictly SJRALP lineage available to be stocked in the San Juan River. Therefore, razorback sucker had to be obtained from other sources. Following the sequential guidelines outlined in the 1997 augmentation plan (Ryden 1997), razorback sucker stocked between 3 September 1997 and 20 October 2000 were either from the nearest geographic neighbor

Table 1. Lineage of and locations reared at for various groups of razorback sucker stocked into the San Juan River between 1994 and 2000.

Stocking Date	Number Of Fish Stocked	Parental Lineage	Area Where Fish Were Reared	Comments
Experimental Stocking:				
1994-1996	939	San Juan River arm of Lake Powell (parents known)	Wahweap hatchery (UDWR-Page, AZ) & Ouray hatchery (USFWS-Ouray, UT)	progeny of paired matings between wild adults; see Ryden 2000 for more detailed information
Total	939 fish stocked			
Augmentation Plan:				
09/03/97	1027	Lake Mohave (parents unknown)	Willow Beach hatchery (USFWS-Willow Beach,AZ)	collected as wild larvae from Lake Mohave
09/17/97	227	Green River X Yampa River (parents known)	Ouray hatchery (USFWS-Ouray, UT)	progeny of paired matings between wild adults
09/19/97	759	Colorado River X “Etter Pond” (parents known)	grow-out ponds in Grand Junction, CO	progeny of paired matings between wild adults
09/19/97	872	Colorado River arm of Lake Powell X “Etter” Pond (parents known)	grow-out ponds in Grand Junction, CO	progeny of paired matings between wild adults
04/22/98	57	Green River (parents unknown)	golf-course ponds in Page, AZ	progeny of stream-side spawnings of wild adults
05/28/98	67	Green River (parents unknown)	golf-course ponds in Page, AZ	progeny of stream-side spawnings of wild adults
10/14/98 and 10/15/98	1155	Lake Mohave (parents unknown)	Ojo Pond near Farmington, NM	collected as wild larvae from Lake Mohave
08/03/99	???	Lake Mohave (parents unknown)	Ojo Pond near Farmington, NM	collected as wild larvae from Lake Mohave
10/17/00 to 10/20/00	1044	Lake Mohave and other various UCRB sources (parents unknown)	Avocet Ponds near Farmington, NM	larvae from Lake Mohave and from matings between upper Colorado River and San Juan River adults
Total	5208 fish stocked			

populations (i.e., the Green and Colorado river populations) or from the razorback sucker population having the most genetic diversity (i.e., Lake Mohave; Dowling and Minckley 1994, Dowling et al. 1996a, 1996b). Table 1 summarizes the specific sources of all razorback sucker stocked between 1994 and 2000.

All razorback sucker listed in Table 1 were first implanted with BioSonics brand Passive Integrated Transponder (PIT) tags. These passive tags require a PIT tag reader. This reader emits a signal from a hand-held wand which strikes the tag and reflects back a unique, ten-digit, alpha-numeric code. Since these tags are passive, they never expire and can be read for the life of the fish.

All razorback sucker intentionally stocked between 1997 and 1999 (i.e., those listed in Table 1) as part of the five-year augmentation effort were stocked immediately downstream of the Hogback Diversion in NM (RM 158.6).

1994-1996

Six stockings of razorback sucker took place between 29 March 1994 and 3 October 1996 (Table 2). Another three stockings of razorback sucker occurred in Lake Powell between 8 August 1995 and 1 November 1995 (Table 2). These three stockings in Lake Powell were not part of the experimental stocking study, but some of the fish associated with these stockings were contacted during subsequent monitoring of experimentally-stocked razorback sucker in the San Juan River. See Ryden 2000a for detailed information on fish stocked between 1994 and 1996 and monitored between 1994 and 1997.

Table 2. Stockings of razorback sucker in the San Juan River and the San Juan River Arm of Lake Powell, 1994-1996, and recaptures that have occurred with these fish as of 31 December 2000. These stockings were part of an experimental stocking study (Ryden 2000a) that predated the development of the 1997 razorback sucker augmentation plan. This table is provided for information on the further monitoring of those fish only. The numbers presented here do not count toward the stocking goals set forward in the 1997 razorback sucker augmentation plan (Ryden 1997).

Date Stocked	Stocking Number	Number Of Fish Stocked	Mean TL(range)	Mean WT(range)	Recapture Information: Number of Recaptures	Recapture Information: Percent of Total Stocked
03/29-30/94	1	15	277(251-316)	260(169-396)	2	13.3%
10/27/94	2	16	403(384-435)	718(580-1018)	2	12.5%
11/16-17/94	3	478	190(100-374)	89(8-512)	4	0.8%
11/18/94	4	177	400(330-446)	715(480-990)	52	29.4%
08/08/95	5	65[a]	405(348-428)	716(452-874)	1	1.5%
08/15/95	6	65[a]	409(369-437)	727(526-871)	2	3.1%
09/27/95	7	16	424(397-482)	794(627-1194)	3	18.8%
11/01/95	8	34[b]	446(419-495)	964(760-1240)	0	0.0%
10/03/96	9	237	335(204-434)	437(90-950)	4	1.7%
Total		939			70[c]	

[a] = The Utah Division of Wildlife Resources stocked 130 razorback sucker, 65 each on 8 August and 15 August 1995, into Lake Powell at Piute Farms (San Juan RM 0.0). They are included here because three of these fish have been recaptured as of 31 December 2000. These fish were not part of the razorback sucker experimental stocking study (Ryden 2000) or the augmentation plan (Ryden 1997) and are not included in numbers discussed in the text of this report. All of these fish were PIT-tagged before stocking.

[b] = The Bureau of Reclamation (Cathy Karp, Denver, CO) and U. S. Geological Survey (Gordon Mueller, Denver, CO) stocked 34 sonic-tagged razorback sucker into Lake Powell on 1 November 1995. Sixteen were stocked at Neskahi Wash (approximately 29 RM below Piute Farms -- RM 0.0) and 18 at Zahn Bay (approximately 10.2 RM below Piute Farms -- RM 0.0). These fish are included here because at least five of them were known to have moved upstream into the lower portion of the San Juan River. However, none were recaptured during electrofishing, seining, or trammel-netting efforts in the San Juan River. These fish were not part of the razorback sucker experimental stocking study (Ryden 2000) or the augmentation plan (Ryden 1997) and are not included in numbers discussed in the text of this report. All of these fish were PIT-tagged before stocking.

[c] = A total of 70 razorback sucker of known origin, stocked before December 1996, had been recaptured as of 31 December 2000. Only sixty-seven of these were part of the razorback sucker experimental stocking study (Ryden 2000). The other three were fish that had originally been stocked in Lake Powell at Piute Farms Marina. An additional eleven razorback sucker were recaptured for which no PIT tag numbers were obtained due to PIT tag reader failure or tag expulsion. The stocking from which these eleven fish originated is unknown. Thus, they are not included in this table. It is likely that one of these unknown-origin fish (captured 21 October 1997), given its size at recapture (216 mm TL), was from a stocking of Lake Mohave fish on 3 September 1997.

1997

There were three stockings of razorback sucker in 1997 (Table 3). The first, on 3 September 1997 consisted of 1027 fish (mean TL = 193 mm, mean WT = 76 g) that had been collected from Lake Mohave as wild larvae. These fish were reared at Willow Beach National Fish Hatchery (NFH)in AZ (Tables 1 and 3).

The second stocking, on 17 September 1997 consisted of 227 fish (mean TL = 229, mean WT = 109 g) that were F_1 progeny of paired matings between wild Green and Yampa river adults. These fish were reared at Ouray NFH until they were stocked (Tables 1 and 3).

The third stocking, on 19 September 1997 consisted of 1631 fish. Of these, 759 were F_1 progeny of paired matings between wild Colorado River and "Etter Pond" adults. "Etter Pond" is an off-channel pond approximately 20 miles upstream of Grand Junction, CO. In 1994, a population of razorback sucker was discovered in this pond. It is assumed that these fish entered this pond in either 1983 or 1984 when the Colorado River flooded the river bottom on which this pond is located. The other 872 fish were F_1 progeny of paired matings between wild Colorado River arm of Lake Powell and "Etter Pond" adults. All 1631 of these fish (mean TL = 185 mm TL, mean WT = none recorded) were reared in grow-out ponds in Grand Junction, CO (Tables 1 and 3).

Table 3. Stockings of razorback sucker in the San Juan River, 1997-2000, as part of the five-year augmentation plan for razorback sucker (Ryden 1997), and recaptures that have occurred with these fish as of 31 December 2000.

Date Stocked	Stocking Number	Number Of Fish Stocked	Mean TL(range)	Mean WT(range)	Recapture Information: Number of Recaptures	Recapture Information: Percent of Total Stocked
09/03/97	1	1027	193(193-240)	76(76-175)	5	0.5%
09/17/97	2	227	229	109	1	0.4%
09/19/97	3	1631	185(104-412)	None Taken	3	0.2%
04/22/98	4	57	420(380-460)	866(612-1108)	7	12.3%
05/28/98	5	67	417(341-470)	874(547-1420)	4	6.0%
10/14-15/98	6	1155	232(185-315)	112(50-280)	2	0.2%
08/03/99	7	?	?	?	3	?[a]
10/17-20/00	8	1044	214(111-523)	None Taken	0	0.0%
Total		5208			25	

[a] = This was an unintentional stocking that occurred when heavy summer rains caused to the dike at Ojo Pond to wash out. The pond completely drained washing all razorback sucker in the pond into Ojo Wash which empties into the San Juan River at RM 170.8. The distance between Ojo Pond and the San Juan River is about six miles. None of these fish were PIT-tagged and the numbers and sizes of these fish at the time of the unintentional stocking are unknown.

1998

There were three stockings of razorback sucker in 1998 (Table 3). The first, on 22 April 1998 consisted of 57 fish (mean TL = 420 mm, mean WT = 866 g) that were progeny of streamside spawnings of wild Green River adults. These fish were reared in golf course ponds in Page, AZ (Tables 1 and 3).

The second stocking, on 28 May 1998 consisted of 67 fish (mean TL = 417 mm TL, mean WT = 874 g) that were progeny of streamside spawnings of wild Green River adults. These fish were also reared in golf course ponds in Page, AZ (Tables 1 and 3).

The third stocking, on 14 and 15 October 1998 consisted of 1155 fish (mean TL = 232 mm TL, mean WT = 112 g) that were originally collected as wild larvae from Lake Mohave in 1997. These fish were reared at Willow Beach NFH, before being transported as age-1 fish to Ojo Pond southwest of Farmington, NM in spring 1998 (Tables 1 and 3). These were the first fish to be reared in a grow-out pond owned and maintained by entities associated with the SJRIP.

1999

No razorback sucker were intentionally stocked in 1999. The fish remaining in Ojo Pond in 1999 (originally stocked into that pond on 15 March 1998) that were not collected in the October 1998 harvest and stocking effort were the only fish scheduled to be stocked in 1999. An additional 17,500 larval razorback sucker from Lake Mohave had been stocked into Ojo Pond on 3 March 1999. These larval fish were scheduled to be stocked in 2001. However, on 3 August 1999, as a consequence of numerous days of extremely heavy rains,

the dike at Ojo Pond washed out, emptying the pond and washing the razorback sucker in the pond into Ojo Wash. It is assumed that most of the larval razorback sucker in Ojo Pond were mortalities. Originally, it was unknown whether any of the larger fish in Ojo Pond were able to negotiate the wash and reach the river (a distance of approximately six miles). There was a flow of about 30 cubic feet per second (CFS) in Ojo Wash the day after the wash-out (R. Smith pers. comm.). A crew from the Farmington Bureau of Indian Affairs Navajo Indian Irrigation Project (BIA-NIIP) office sampled Ojo Wash on 4 August, recovering approximately 200 razorback sucker larger than 200 mm TL (E. Teller pers. comm.). These fish were transported to the east cell of Avocet Ponds. By the next day, 5 August, approximately 75% of the razorback sucker recovered from Ojo Wash on 4 August and stocked in East Avocet Pond had died (E. Teller pers. comm.).

Subsequent electrofishing and seining (on 23 and 24 September 1999) in the mainstem San Juan River both up- and downstream of the area of the San Juan River into which Ojo Wash empties, failed to collect any razorback sucker. However, on 21 September 2000, three unmarked razorback sucker (i.e., no PIT tags) were collected at RM 169.0 (1.8 RM downstream of the Ojo Wash confluence; Table 3). So, at least some of the fish from the Ojo Pond washout have survived and made their way into the San Juan River. However, the numbers and sizes of these unintentionally-stocked razorback sucker are unknown.

2000

Between 17 and 20 October 2000, 1,044 razorback sucker were harvested from the Avocet Ponds and stocked (Table 3). These 1,044 fish consisted of

fish from at least three different year-classes: 1997 (n = 8); 1999 (n = 206); and 2000 (n = 830). Overall, the mean TL for all 1,044 fish was 214 mm (Table 3). No weights were taken for these fish. The 1997 year-class fish were survivors from the Ojo Pond washout (on 3 August 1999) that were collected from Ojo Wash and placed into the Avocet Ponds on 4 August 1999. These eight fish (mean TL = 482 mm, range = 460-523 mm; Figure 2), were originally collected as larvae from Lake Mohave. The 206 1999 year-class fish (mean TL = 373 mm, range = 280-450 mm; Figure 2) were of mixed lineages, including Lake Mohave, and crosses between adults from the San Juan River Arm of Lake Powell and various Colorado River locations (Ryden 2000c). The 830 2000 year-class fish (mean TL = 172 mm, range = 111-225 mm; Figure 2) were also of various lineages including Green River, Colorado River, and San Juan River Arm of Lake Powell.

Grow-Out Ponds

In response to shortfalls in numbers of razorback sucker being stocked, the SJRIP acquired use of three ponds on BIA-NIIP land southwest of Farmington, NM in 1998. The first, Ojo Pond was enlarged from its original size of 1.8 surface acres to 2.4 surface acres and a depth of six feet (Keller-Bliesner Engineering 1998). Ojo Pond was filled with water and was “online” in spring 1998. This pond was first stocked with fish on 15 March 1998 and again on 3 March 1999 (Table 4). A total of 1155 razorback sucker were harvested from this pond and stocked into the San Juan River at RM 158.6 on 14 and 15 October 1998 (Tables 3 and 4). Due to unseasonably heavy rains, Ojo Pond washed out on 3 August 1999. This pond was not rebuilt.

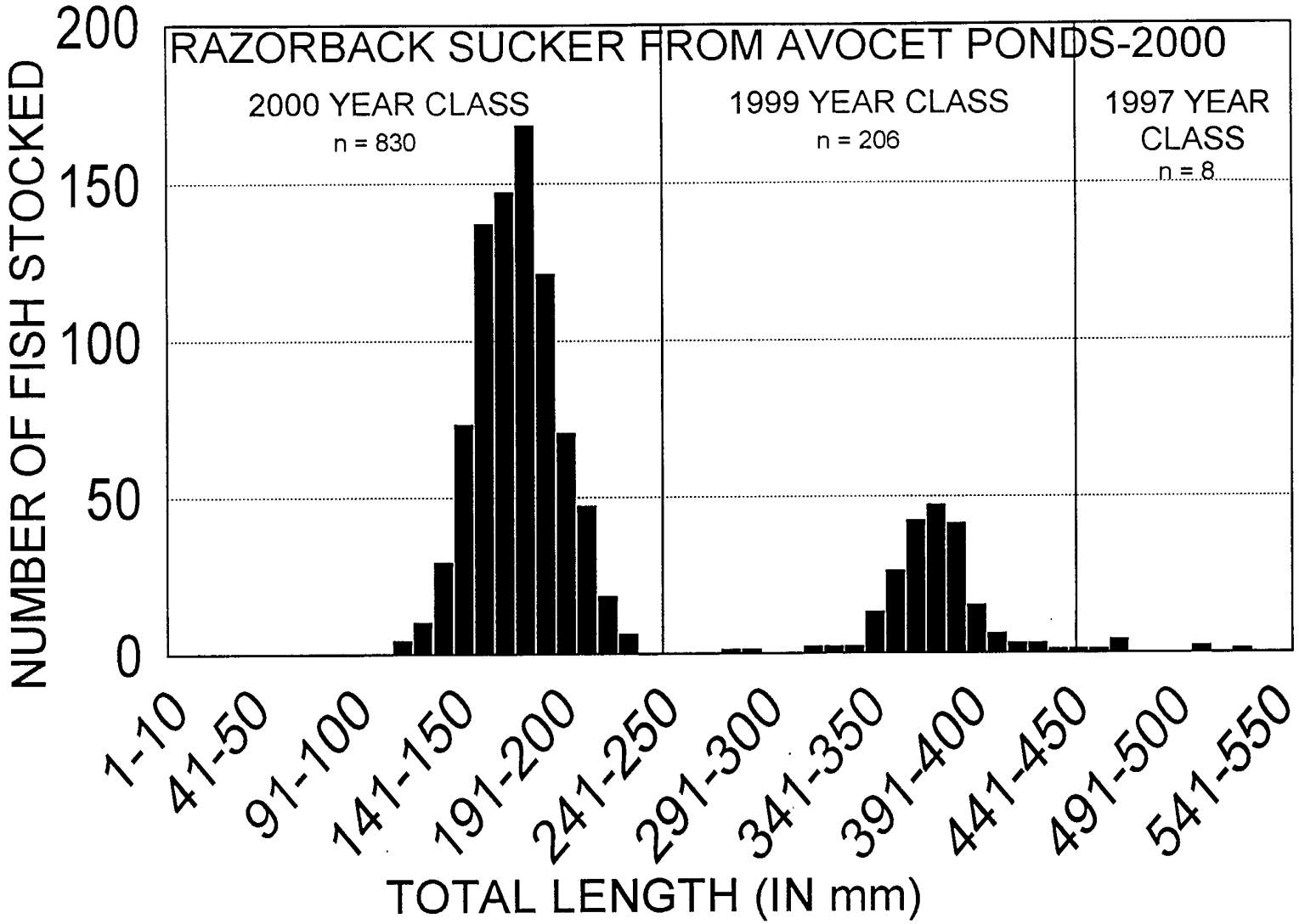


Figure 2. Sizes and year-classes of razorback sucker stocked into the San Juan River in 2000. All fish were stocked just downstream of Hogback Diversion at RM 158.6.

Table 4. History of fish stocked into the Avocet Ponds and Hidden Pond in 2000. All fish stocked into ponds in 2000 were 2000 year-class larvae.

Pond Name	Family Lot	Number Of Fish Stocked	Female[a] Parent(s) Lineage	Male[a] Parent(s) Lineage
West Avocet	2003	10,000	1991 Year Class Green River	Colorado River (“Grand Valley Old Broodstock”)
West Avocet	2014	10,000	1991 Year Class Green River	San Juan River Arm of Lake Powell (92-3A)[a]
East Avocet	2004	10,000	94-A[a]	Green River: Wild Fish
East Avocet	2004	10,000	1991 Year Class Green River	94-D[a]
Hidden Pond	2007	5,000	94-E[a]	Green River: Wild Fish
Hidden Pond	2008	5,000	Green River: Wild Fish	94-A[a]
Hidden Pond	2009	10,000	1991 Year Class Green River (2 females)	94-B[a]
Hidden Pond	2016	5,000	San Juan River Arm Of Lake Powell (92-3E)[a] --(2 females)	1991 Year Class Green River
Hidden Pond	2017	10,000	San Juan River Arm Of Lake Powell (92-2A)[a] --(2 females)	1991 Year Class Green River
Hidden Pond	2019	5,000	Green River: Wild Fish	94-F[a]
Hidden Pond	2020	10,000	1991 Year Class Green River (2 females)	San Juan River Arm Of Lake Powell (92-2A)[a]
Hidden Pond	2023	5,000	9501[b]	San Juan River Arm Of Lake Powell (92-3E)[a]
Hidden Pond	2024	5,000	9515[b]	San Juan River Arm Of Lake Powell (92-2B)[a]

[a] = The “92" in parentheses indicates that this fish is of San Juan River Arm of Lake Powell lineage. The prefix “94" in parentheses indicates that this fish is of either Grand Valley (i.e., Colorado River at Grand Junction, CO) or Colorado River Arm of Lake Powell lineage.

[b] = These two lots were of mixed origin. Lot 9501 from which this female came was a cross between a Grand Valley (i.e., Colorado River) female and a Colorado river Arm of Lake Powell male. Lot 9515 from which this female came was a cross between a San Juan River Arm of Lake Powell female and a Grand Valley (i.e., Colorado River) male.

Two other ponds currently being used by the SJRIP to rear razorback sucker are the Avocet Ponds. These ponds are also located on BIA-NIIP land southwest of Farmington, NM. These ponds were created by dividing a large existing dry basin into two smaller ponds (Keller-Bliesner Engineering 1998). The west pond is 3.34 surface acres with a depth of six feet. The east pond is 3.52 surface acres, and six feet deep. These ponds were filled with water in fall 1998, but because they had been dry for so long, they were not considered to be "online" until spring 1999. This allowed the ponds time to develop the productivity needed to support razorback sucker. East Avocet Pond was stocked with fish on 3 March 1999 (Ryden 2000c). West Avocet Pond was stocked with fish on 25 May 1999 (Ryden 2000c). Both Avocet Ponds were again stocked with fish (n = 20,000 per pond) on 24 May 2000 (Table 4).

In 1999 a fourth pond, Hidden Pond, was constructed to replace Ojo Pond. Hidden Pond has 2.83 surface acres and is six feet deep. Hidden Pond was still in the process of being filled when it was stocked on 25 May 2000 with 60,000 larval razorback sucker (Table 4). The fish in Hidden Pond are not scheduled to be harvested and stocked until fall 2001.

Monitoring Of Stocked Fish

Radio Telemetry

Two types of radio telemetry contacts were made with razorback sucker, habitat observation contacts and movement contacts. Habitat observation contacts consisted of locating a fish via radio telemetry and monitoring its movement for a minimum of one hour. During this time, the amount of time the

fish spent in each habitat type and all movements made by the fish were marked on a transparent acetate sleeve laid over a hardcopy of aerial videography of the river channel that matched the flow in the river at that time. At the end of one hour, all available habitats were mapped (for the entire width of the river channel) at the fish location and from 100 meters upstream of the fish's most upstream location during the contact period to 100 meters downstream of the fish's most downstream location during the contact period (i.e., the "contact area"). Habitat classifications used for mapping were those defined by Bliesner and Lamarra (1993). Upon return from the field, the transparent sleeves were laid over a small-scale grid and relative percentages of each habitat type available to a given fish at the location area were determined.

Habitat and water quality data were also collected at the habitat observation locations. Data recorded included depth, velocity, substrate, water clarity, cover type, and distance from fish location to potential cover. Water quality parameters recorded were main channel (MC) and habitat water temperatures, dissolved oxygen (DO), conductivity, pH, and salinity. At the end of a habitat observation an attempt was made to recapture the radiotelemetered fish by trammel netting or seining to obtain growth and associated fish community information. This sampling also helped determine if the fish in question demonstrated an avoidance behavior and was, therefore, alive.

To determine if adult razorback sucker select particular habitat types, habitat use was compared to habitat availability (Swanson et al. 1974, Johnson 1980, Osmundson et al. 1995). Selection, or lack thereof, for a particular habitat type was estimated by the average difference between the percent that each individual habitat type contributes to the total water area available to an individual fish (within a given contact area) and the percent frequency of use of each individual habitat type by each individual fish. If there is no selection, fish should be located in the various habitat types at the same

frequency as the occurrence or availability of those habitat types. For example, if 20% of the total water area is comprised of pool habitat, one would expect 20% of the fish locations to be in pools if habitat use was random (i.e., no selection). If a fish exhibits a selection for certain habitat types (i.e., more use than availability would predict), it is assumed that those habitat types are important in fulfilling some biological need for the fish.

To determine habitat selection, relative percentages for every individual habitat type available to a given fish at each individual fish location were determined. Relative percentages of time that fish spent using each habitat type during the radiotelemetry contact were also determined. Percent availability of each individual habitat type within a given contact area was subtracted from the percent use of that habitat type by that fish. Differences between the two percentages were then averaged across all fish in a given calendar month, riverwide, all years combined. This follows the 'aggregate percent method' (Swanson et al. 1974) that greatly reduces biases associated with unequal numbers of contacts among sampled fish. In addition, analyses involving a limited number of fish observations are greatly enhanced if observations made during many months (i.e., the same calendar month over many years) can be pooled to increase sample size (Osmundson et al. 1995). This mean difference between percent use and percent availability, called the "weight value", was then used as a measure of the degree of selection for each individual habitat type. Those habitat types with positive weight values (>0) were considered to be selected for; the higher the value, the more selected for. Negative weight values were interpreted simply as a lack of selection for a specific habitat type rather than an active avoidance of it (Osmundson et al. 1995). After weight values were determined, negative weight values were dropped from further analysis and all positive weight values for a given month were ranked in descending order to determine the relative importance of

selected habitats within a given month. All positive weight values within a given month were then converted to a scale of 100% to make it easier to interpret the relative degree of selection between selected habitats.

It was also assumed that the combination of habitats, adjacent to one another, would play a role in a fishes site selection process. Habitat richness, the number of individual available habitat types observed (i.e., mapped) within each contact area during each individual fish contact, was averaged across all contacts in a given calendar month, riverwide, all years combined. The habitat richness value for each month determines the number of habitat types it is felt to be important to manage for adult razorback suckers. For example, if the mean habitat richness for all June contacts, all years combined, was six, we assume that a block of six habitat types is therefore important in fulfilling a biological need for the fish.

The second type of radio telemetry contact, movement contacts, consisted simply of recording the radio tag number, date, and RM of contact. On occasion, more information was recorded, but this was usually not the case.

Both types of contacts were used to calculate values for total longitudinal movement, or TLM (i.e., the total number of RM moved, from the most upstream contact to the most downstream), maximum displacement, or MD (i.e., the maximum distance moved from the point of release during entire monitoring period), and final displacement, or FD (i.e., the distance from point of release to point of last contact). For fish that were tracked prior to the beginning of the augmentation effort, TLM, MD, and FD were calculated using all contacts with that fish.

Recaptures

Razorback sucker monitoring trips had the following sampling protocol. Electrofishing proceeded downstream in a continuous fashion from put-in (RM 158.6) to take-out (RM 76.4) with two electrofishing rafts. One netter stood on an elevated platform above the anodes and collected fish as they were drawn into the electrical field. The raft operator maneuvered the boat via oars, monitored the Variable Voltage Pulsator (VVP), and made adjustments to current, voltage, amperage, frequency, and pulse width when necessary. Rafts were oriented perpendicular to the shoreline with the anode nearest the shoreline. One raft shocked along each shoreline of the river, breaking off into large secondary channels, when they were accessible. Particular mid-channel features such as debris piles, cobble bars, and island shorelines were also shocked where they were present at the raft operators discretion.

The study area was divided into one-mile sections. Electrofishing crews began at the upstream end of each mile and collected all the fish they could net as they shocked downstream. At the end of each mile, all non-rare fish collected were enumerated by species and age class. All nonnative fish species collected during sampling were removed from the river, in support of the nonnative removal study. Common native fishes were returned alive to the river.

Captured specimens of rare native fish (razorback sucker, Colorado pikeminnow, and roundtail chub) were anesthetized using MS-222 (200 mg/L of water), weighed, measured, checked for a PIT tag, and examined for general health and reproductive status (if apparent). If no PIT tag was detected, one was implanted. River mile of capture (to the nearest 0.1 RM) was noted, if specifically known. In many electrofishing samples the crew was unaware that they had collected a rare fish until the end of the sample when fish were

being sorted. In these instances, the exact collection location was impossible to determine, so the point of release was used to determine displacements from point of stocking. All rare native fishes were returned alive to the river after data collection was complete.

Razorback sucker were also recaptured, incidentally, via electrofishing on main channel adult fish community monitoring trips (USFWS), and rare fish population goal sampling trips (Ecosystems Resource Institute {ERI} and Miller Ecological Consultants {MEC}), via seine on trips to monitor stocked Colorado pikeminnow (Utah Division of Wildlife Resources {UDWR}), and via trammel net during rare fish surveys in Lake Powell (U.S. Geological Survey-Biological Resources Division {USGS-BRD}).

Razorback sucker that had been recaptured two or more times since their date of stocking were used to examine movement patterns. The reason for using fish recaptured more than once was to try to examine fish that had adapted to living in the river and were displaying “natural” behaviors. Based on previous data, large initial downstream displacements observed among radiotelemetered razorback sucker after stocking were usually followed by fish demonstrating the ability to maintain their relative position in the river with many even moving back upriver (Ryden 2000a). Since only two data points were available for first-time recaptures, it could not be determined if these fish were still in the process of that initial downstream displacement or had already adjusted to riverine conditions.

RESULTS

Stocking Shortfalls

Between September 1997 and December 2000, 5208 razorback sucker were stocked into the San Juan River at RM 158.6. This equates to a shortfall of 50,124 fish over the four-year period, i.e., only 9.41% of the number of razorback sucker called for in the 1997 augmentation plan have been stocked, a 90.59% shortfall (Table 5). Including the 939 razorback sucker stocked as part of the experimental stocking study, 6147 total razorback sucker were stocked into the San Juan River between 29 March 1994 and 31 December 2000.

Monitoring Of Stocked Fish

Two razorback sucker monitoring trips (i.e., electrofishing) were conducted in 2000, one in May and one in July. The May trip sampled RM 158.6-76.4 from 1-5 May 2000. Three razorback sucker were collected on that trip (Table 6). The July razorback sucker monitoring trip was scheduled to sample the same RM from 24-28 July 2000. However, because of extremely low flows, the trip was cut short after only sampling from RM 147.9-129.0. No razorback sucker were collected on that trip, however, 279 striped bass were collected.

All 279 striped bass collected on the July 2000 trip were adult fish. A subsample of 25 measured striped bass had a mean TL of 499 mm (range = 456-545 mm TL). Sex was determined for 16 of these fish, all were females. Of the 16 stomach samples taken, six were empty. However, the other ten stomachs

Table 5. Numbers of fish projected to be stocked in the 1997 augmentation plan versus actual numbers of razorback sucker stocked into the San Juan River, 1997-2000.

Year	Number Of Fish Projected To Be Stocked	Actual Number Stocked And (Shortfall)	Percent Of Projection Actually Stocked	Percent Shortfall
1997	31,800	2,885 (28,915)	9.07%	90.93%
1998	12,720	1,279 (11,441)	10.06%	89.94%
1999	10,812	0 (10,812)	0.00%	100.00%
2000	9,286	1,044 (8,242)	11.20%	88.80%
2001	8,864	None Yet (None)	-----	-----
To-Date Totals 1997-2000	55,332	5,208 (50,124)	9.41%	90.59%

Table 6. General information on stocked razorback sucker recaptured in the San Juan River during 2000 sampling (® = a fish that has been recaptured more than once since being stocked).

Recapture Date	PIT tag number	Stock[a]	Radio Tag	Old TL(mm)	Old WT(g)	New TL(mm)	New WT(g)	Days In River	River Mile Recapture	River Mile Stocking	Sex[b]
USFWS May 2000 Razorback Sucker Monitoring Trip (Electrofishing)											
05/01/00	7F7D175C49®	SJRALP	None	337	454	398	740	1306	141.0	158.6	F
05/03/00	507F727F1E	Mohave	None	232	112	469	1500	567	115.0	158.6	M
05/04/00	7F7D1B6654	SJRALP	639	274	241	449	760	2228	88.0	117.5	M
USGS-BRD and UDWR summer 2000 Lake Powell Trammel Netting											
06/06/00	1F41482038	SJRALP	None	367	----[c]	492	1294	2027	0.0	158.6	I
06/06/00	7F7B11352B	Green	None	441	1021	485	982	776	0.0	158.6	M
06/06/00	1F6B2B7356	SJRALP	None	405	773	472	1202	1757	0.0	0.0[d]	I
06/07/00	1F732D724F®	SJRALP	None	420	870	505	1392	2028	-4.1	136.6	M
07/18/00	1F43686353®	SJRALP	475	427	930	522	1540	2091	0.0	79.6	M
USFWS October 2000 Main Channel Adult Fish Community Monitoring Trip (Electrofishing)											
09/21/00	None[e]	Mohave	None	---	----	410	820	415	169.0	170.8	I
09/21/00	None	Mohave	None	---	----	380	615	415	169.0	170.8	I
09/21/00	None	Mohave	None	---	----	351	457	415	169.0	170.8	I
10/02/00	420F365F58®	CALP/EP	751	325	----	474	1120	1109	108.7	158.6	I
10/03/00	1F43597253	SJRALP	831	395	690	510	1400	2146	100.0	158.6	M
10/03/00	42131C4420	CALP/EP	811	266	----	508	1400	1110	100.0	158.6	F
10/04/00	1F743D161A	SJRALP	820	393	710	422	1800	2147	77.0	117.5	M
10/09/00	7F7B124458	Green	791	415	760	483	1005	901	11.0	158.6	M

[a]: Mohave = fish harvested as wild larvae from Lake Mohave; CALP/EP = progeny of paired matings between wild adult razorback sucker from the Colorado River arm of Lake Powell and from Etter Pond near Grand Junction, CO; SJRALP = progeny of paired matings between wild adult razorback sucker from the San Juan River arm of Lake Powell; Green = progeny of streamside spawnings of wild adult Green River razorback sucker; GR/YR = progeny of paired matings between wild adult razorback sucker from the Green and Yampa rivers.

[b]: I = Indeterminate, M = Male, F = Female

[c]: These values were not available due to equipment failure or lack of a PIT tag reader on the trip.

[d]: This fish was stocked by the Utah Division of Wildlife Resources (UDWR) at Piute Farms (RM 0.0) in Lake Powell on 15 August 1995. This fish was not a part of this riverine augmentation effort. It is listed here because it was collected in the same backwater (and trammel net) as a fish from our stocking effort.

[e]: No PIT tag could be detected in these fish at the time of recapture. The area in which these fish were recaptured, their size, appearance, and general health were indicative of fish inadvertantly stocked when Ojo Pond washed out on 3 August 1999.

included both native (speckled dace and flannelmouth sucker) and nonnative fish (channel catfish and common carp), as well as crayfish.

Thirteen additional razorback sucker were recaptured during sampling trips for other research elements (Table 6).

Between September 1997 and December 2000, 22 (0.4%) of the 5208 razorback sucker stocked as part of the five-year augmentation effort were recaptured (Tables 3 and 6, Ryden 2000c). Twenty-one of these fish were first-time recaptures and one has been recaptured twice since stocking. Three other razorback sucker that had been inadvertently stocked into the San Juan River when Ojo Pond washed out (in 1999) were also recaptured at RM 169.0 in 2000 (Table 6). All three of these fish were first-time recaptures.

In addition 25 (2.7%) of the 939 razorback sucker stocked during the experimental stocking study (and not reported in Ryden 2000a) were also recaptured between September 1997 and December 2000 (Tables 2 and 6, Ryden 2000c). Of these 25, 14 were first time recaptures, eight were recaptured for the second time since being stocked and three were recaptured for the third time since being stocked.

Two of the 65 razorback sucker stocked into Lake Powell at Piute Farms (RM 0.0) on 15 August 1995 were also recaptured between 1997 and 1999 (Tables 2 and 6, Ryden 2000c). Both of these were first-time recaptures. An additional six razorback sucker for which no identifying PIT tag number was obtained were also recaptured between 1997 and 1999 (Ryden 2000c). The origin of these six recaptured fish (i.e., stocking date and location) was unknown.

Of the 22 recaptured known-origin razorback sucker associated with the five-year augmentation effort, 18 (81.8%) were collected during various electrofishing efforts. The other four (18.2%) were collected in trammel nets. Of the 52 total known-origin razorback sucker collected (including Lake Powell fish), 43 (82.7%) were recaptured by electrofishing, 9 (17.3%) by trammel net. For all 58 recapture events (including the six unknown-origin

fish), 48 (82.8%) were recaptured via electrofishing, 9 (15.5%) using trammel nets, and one (1.7%) in a seine.

In addition to the razorback sucker collected, two Colorado pikeminnow stocked by the UDWR between 1996 and 1998 were recaptured on razorback sucker monitoring trips, one each in May and July 2000 (Table 7). One of these fish, recaptured at RM 137.3 on 25 July 2000 (404 mm TL) had previously been recaptured at RM 75.0 on 5 October 1998 (282 mm TL). No roundtail chub were collected during razorback sucker monitoring trips.

Habitat Use, Needs, Selection, And Richness

In October 1999, four adult razorback sucker were implanted with radio transmitters (tags). These fish were to be tracked in the spring of 2000, to observe movements and habitat use during the presumed spawning season. These four fish were implanted at RM 88.0, 76.4, 59.4, and 55.3. After implantation, only one of these fish was contacted again. This fish (radio tag # 771), originally tagged at RM 76.4 on 1 October 1999, moved downstream and was contacted at RM 64.7 on 14 March 2000 and RM 65.4 on 20 June 2000. During the two contacts with this fish, it was using deep (> 3.0 ft deep), swift, main channel run habitat with shifting sand substrate. It did not appear to be displaying spawning behavior during either contact.

In October 2000, five more adult razorback sucker were implanted with radio tags at RM 108.7, 100.05, 100.05, 77.0, and 11.0. Two of these fish (a male and female implanted at RM 100.05) were contacted at the suspected spawning area (at RM 100.2) as late as 23 January 2001. Data on the movements and habitat use of these five fish will be presented in our annual report for 2001 field activities.

Table 7. Information on other rare fishes collected from the San Juan River during razorback sucker monitoring trips in 2000.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Recaptured, stocked Colorado pikeminnow:						
05/04/2000	512737211D	None	220	90	I	97.0
07/25/2000	7F7B113D5C®	None	404	425	I	137.3

® = This was a recapture of a fish that was previously captured and PIT-tagged.

Site Preference

Data for site preference among stocked razorback sucker at two sites is growing. Groupings of razorback sucker sampled at two locations in the San Juan River may indicate preference for a specific site in the river. The first possible preferred site is just downstream of Aneth, UT at RM 100.2 on river right (Figure 3). The collection of three ripe male razorback sucker and observation of three more razorback sucker that were not collected in May 1997 at this site was reported upon in Ryden 2000a (Figure 3). A fourth ripe male razorback sucker was also collected just upstream of this site on the same side of the river at RM 100.5, the confluence of McElmo Creek (Figure 3; Ryden 2000a). This fish was also contacted via radio telemetry at RM 100.0 on 3 October 1996 (Figure 3).

No razorback sucker were collected at this site during sampling on 7 May 1998. However, in April 1999, two ripe male razorback sucker and one gravid female razorback sucker were collected at this same site within a few feet of where the three razorback sucker were collected in May 1997 (Figure 3). Like the razorback sucker collected in May 1997, the three razorback sucker collected in April 1999 were in the midst of numerous ripe (presumably spawning) flannelmouth sucker, over an embedded cobble substrate, approximately 5-10 feet from the river right bank in less than three feet of water. These three fish, all stocked on 18 November 1994 had been stocked at three different stocking sites (RM 158.6, 177.5, and 79.6).

On 3 October 2000, two adult razorback sucker, a male (510 mm TL) and female (508 mm TL) were collected at RM 100.05 just downstream of the suspected spawning area. The male had been stocked at RM 158.6 in November 1994 and the female at RM 158.6 in September 1997. Both were implanted with radio tags and released. Since that time these two fish have remained in the

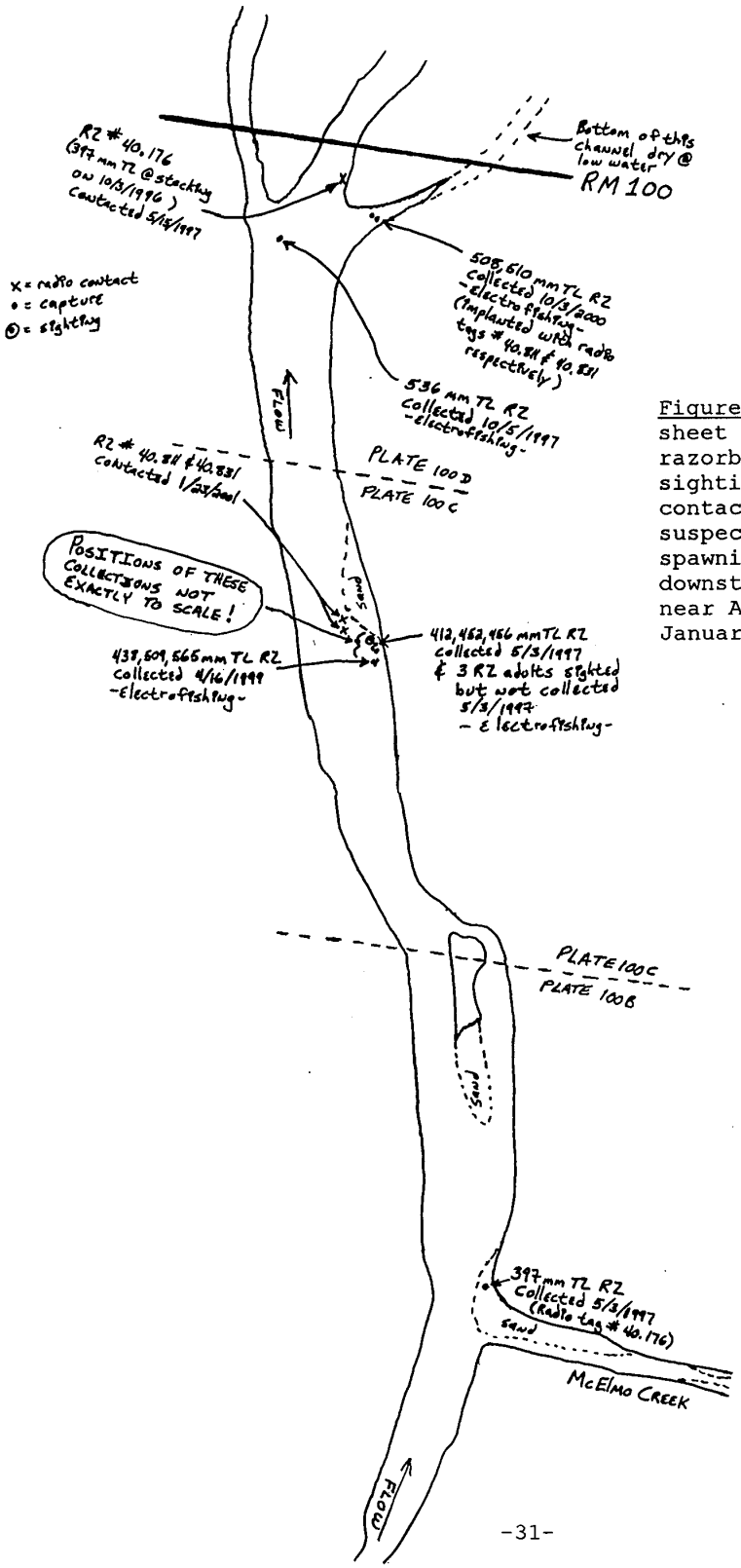


Figure 3. Copy of field data sheet showing the locations of razorback sucker recaptures, sightings, and radio telemetry contacts centered around a suspected razorback sucker spawning area (RM 100.2) just downstream of McElmo Creek, near Aneth, Utah, May 1997 to January 2001.

area, moving upstream to within a few yards (on 23 January 2001) of where the aggregations of ripe fish were collected in spring 1997 and 1999.

The second possible preferred site for razorback sucker is centered around a large backwater (a side channel at higher flows) at RM 77.3 on river left just upstream of Sand Island boat launch (Figure 4). On 21 October 1997, an immature razorback sucker (216 mm TL) was seined from this backwater by a crew from UDWR. Flows at Shiprock USGS gage at the time of this recapture were 1110 CFS. Although no PIT tag number was read for this fish, it is likely that this fish was a razorback sucker (Mohave stock) that had been stocked on 3 September 1997 at RM 158.6. The following year on 5 October 1998, a male razorback sucker (444 mm TL) was collected along the river left shoreline just upstream of the top of this backwater (RM 77.5) and a second male razorback sucker (423 mm TL) was collected at the mouth of the backwater (RM 77.3; Figure 4). The flows at the Shiprock USGS gage at the time of this recapture were 821 CFS and the backwater was almost completely dry. A third razorback sucker was observed but not netted at the mouth of the backwater. These two male razorback sucker were originally stocked on 18 November 1994 as part of the experimental stocking study at two different stocking sites, RM 158.6 and 79.6. On 4 October 2000, a male razorback sucker (422 mm TL) was recaptured at RM 77.0 and implanted with a radio tag. It has since moved upstream and was contacted at the mouth of this backwater on 24 January 2001 (Figure 4). The backwater was dry at the time of this contact. In 1994, a radio-tagged juvenile razorback sucker was also contacted near this backwater three times, once downstream and twice upstream (Figure 4).

There have been a total of 122 razorback sucker recaptures between 1994 and 2000, including first-, second-, and third-time recaptures of known-origin razorback sucker, recaptures of unknown-origin razorback sucker (no PIT tag read), and recaptures of razorback sucker that had moved upstream from Lake

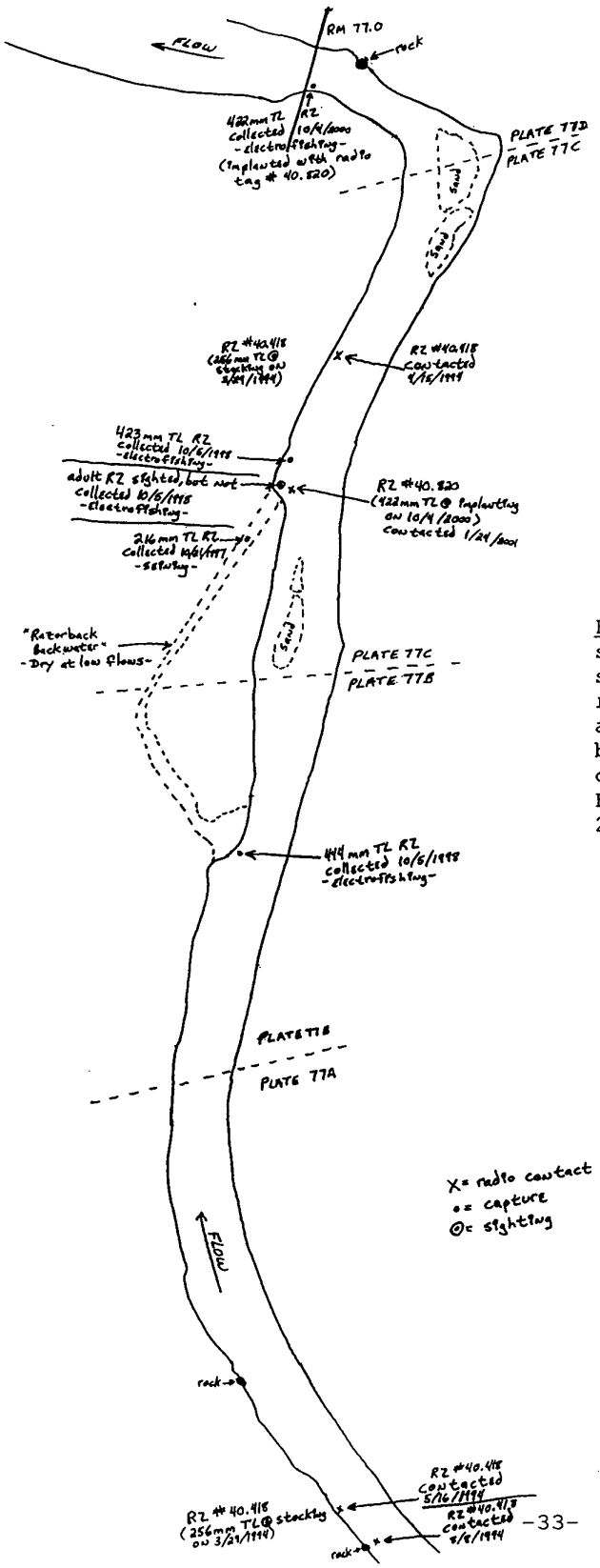


Figure 4. Copy of field data sheet showing the locations of razorback sucker recaptures, sightings, and radio telemetry contacts centered around the "razorback sucker backwater" (RM 77.3) just upstream of Sand Island boat launch, near Bluff, Utah, May 1994 to January 2001.

Powell into the San Juan River. Of these 122 recaptures 65 (53.3%) occurred between RM 130.0 and 80.0 (Figure 5). Twenty-five of the 122 (20.5%) occurred between RM 110.0 and 100.0 (Figure 5). This is the ten-mile section of river in which the suspected spawning area (at RM 100.2) occurs. Only 25 (20.5%) of the 122 recaptures occurred upstream of RM 130.0, while another 32 (26.2%) of the 122 recaptures occurred downstream of RM 80.0 (Figure 5). Though not technically site preference, the large number of recaptures in the 50-RM section, centered around Aneth, UT, indicates that conditions there are very suitable for the retention and survival of stocked razorback sucker.

Movement Patterns

Movement data was only obtained for one radio-tagged razorback sucker in 2000. This fish moved downstream after being implanted and remained downstream of its release location until contact with it was lost in late June 2000. The downstream movement observed after radio tag implantation was likely attributable to stress associated with surgery. This fish did not display any behavior that appeared related to spawning. TLM for this fish was 11.7 miles, MD = -11.7 miles (the {-} means downstream movement), and FD = -11.0 miles. The other three razorback sucker that were tagged in October 1999 were never contacted after release, so no movement data was obtained for these three fish.

The 57 razorback sucker recaptures from October 1997 to December 2000 ranged from RM 169.0, upstream of PNM Weir, downstream to Lake Powell (RM -4.1; Table 6, Ryden 2000c). Four razorback sucker have now been recaptured upstream of Hogback Diversion (the upstream limit of Critical Habitat for this species in the San Juan River). The three razorback sucker collected at RM

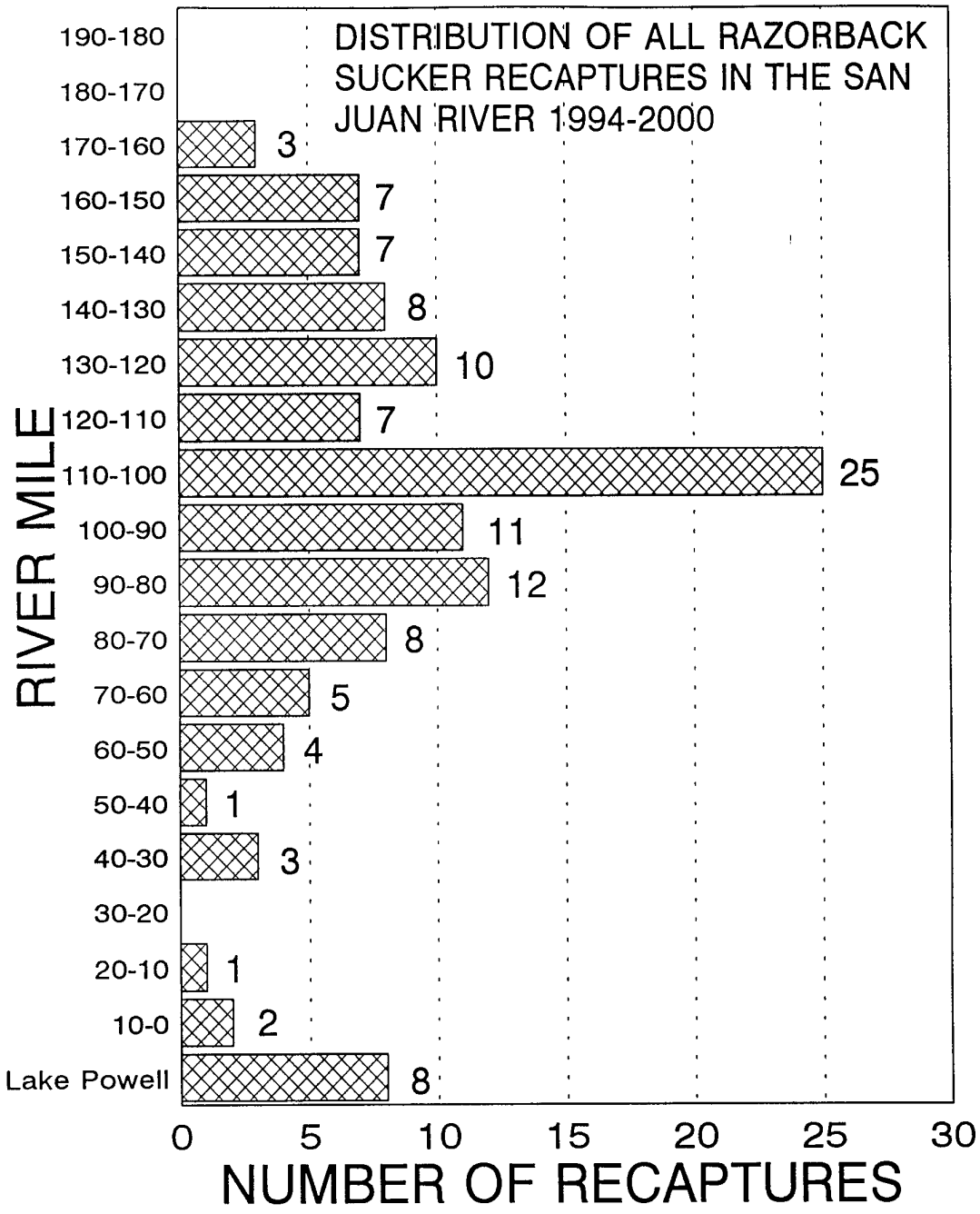


Figure 5. Longitudinal distribution of all razorback sucker recapture events (including second- and third-time recaptures) in the San Juan River between March 1994 and December 2000, by ten-RM increments. Numbers to the right of the bars represent the actual number of recapture events.

169.0 were from an inadvertent stocking, and had entered the river at RM 170.8 (the Ojo Wash confluence), moving downstream 1.8 RM from where they had entered the river. The fourth fish that was collected upstream of Hogback Diversion (recaptured at RM 159.0), was a 193 mm TL fish stocked as part of the five-year augmentation effort that had only been in the river for 26 days when recaptured (Ryden 2000c). This is the only record of a stocked razorback sucker having moved upstream of the Hogback Diversion stocking site (i.e., RM 158.6). However, it should be noted that the Hogback Diversion had largely been destroyed by river flows and had not yet been rebuilt when this upstream passage took place (pers. obs.). The other 21 recaptured razorback sucker associated with the five-year augmentation effort all initially moved downstream after stocking (mean = 82.3 RM, range = 7.5-158.6 RM). Only one razorback sucker stocked as part of the augmentation effort, has been recaptured for a second time since stocking. Another twelve razorback sucker stocked as part of the experimental stocking study were recaptured for either the second (n = 9) or third (n = 3) time post-stocking during the 1995-2000 time period. Movements of these thirteen fish all consisted of an initial downstream displacement, after which nine (69.2%) of the thirteen moved upstream (Figure 6). One of the other three managed to maintain its relative position in the river after the initial downstream displacement. The other three continued to be recaptured farther downstream, with two eventually being recaptured in Lake Powell. Two of these fish, stocked at separate stocking sites in the fall of 1994, were recaptured in a suspected spawning aggregation at RM 100.2 on 16 April 1999 (Figure 6).

Four razorback sucker stocked as part of the five-year augmentation effort were collected in trammel nets at or near the San Juan River-Lake Powell interface (RM 0.5-0.0), in 1999 and 2000. These four fish (425-445 mm TL at stocking), had been stocked at RM 158.6 from 482-776 days earlier. Another three razorback sucker stocked as part of the experimental stocking

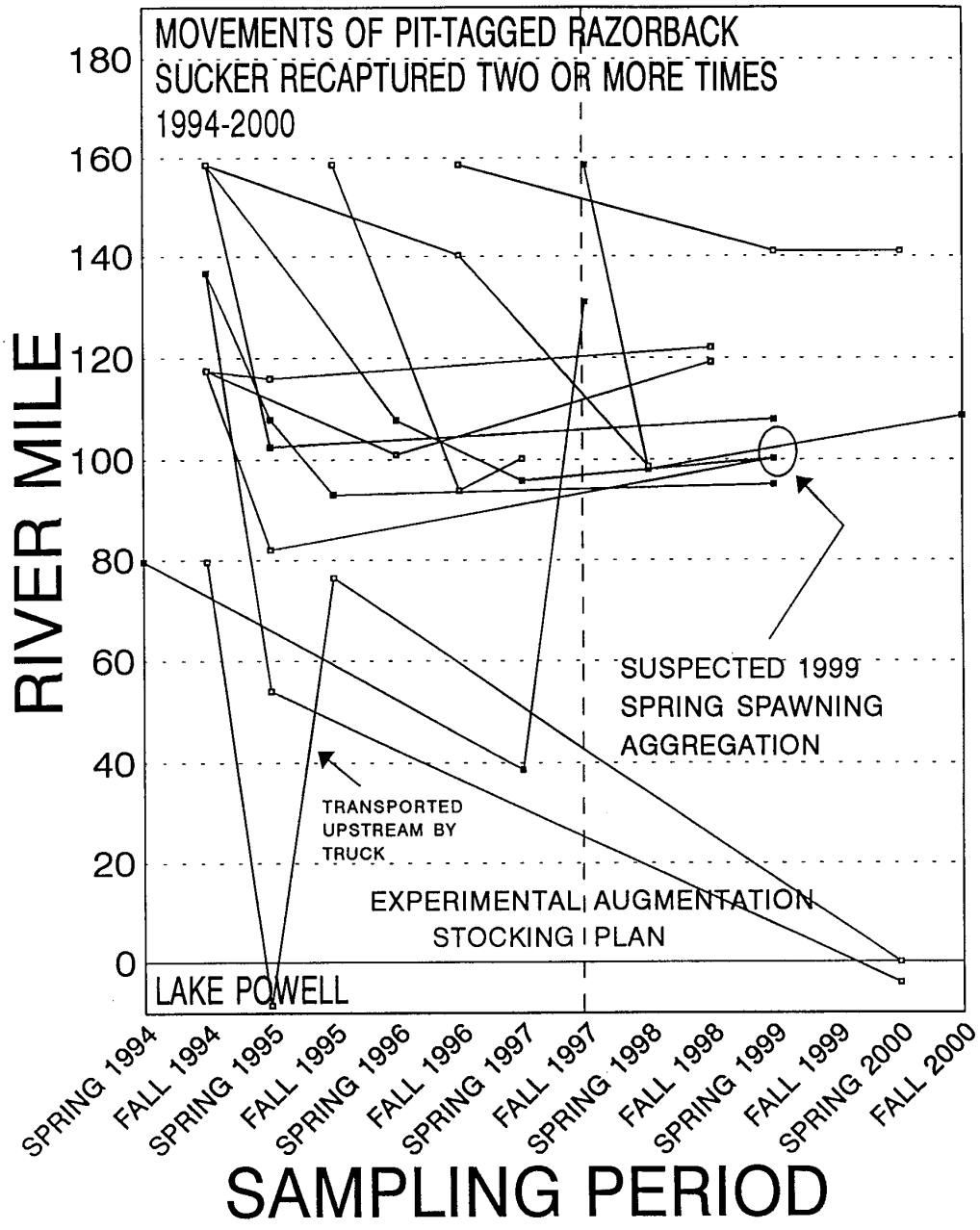


Figure 6. Movements of PIT-tagged razorback sucker recaptured two or more times since their stocking date, 1994-2000.

study (1994-1996) were collected in Lake Powell (RM -8.5 to 0.0) between 1995 and 2000. These three fish (367-427 mm TL at stocking) had all been stocked at different sites (RM 79.6, 136.6, and 158.6) from 140-2091 days before recapture in Lake Powell. In addition, two razorback sucker that were stocked into Lake Powell (at RM 0.0) in 1995 have also been recaptured. One was recaptured in 1999 at RM 0.5 (412 mm TL at stocking) and one in 2000 at RM 0.0 (405 mm TL at stocking). These recaptures demonstrate that no matter what size-class of razorback sucker are stocked, a certain percentage of them will move downstream until they enter Lake Powell.

DISCUSSION

Habitat Use, Needs, Selection, And Richness

Habitat use data was only collected for a single razorback sucker in 2000. This fish (radio tag # 771) was contacted at RM 64.7 on 14 March 2000 and at RM 65.4 on 20 June 2000. During both contacts this fish was using deep, swift, main channel run habitats with shifting sand substrates. Its observed behavior was not exemplary of what has been observed for other radiotelemetered razorback sucker that tend to use more varied habitat types during these two months. These behaviors have also not been exemplary of habitat use anticipated for spawning adult razorback sucker.

Site Preference

Evidence for site preference at two locations sites in the San Juan River continues to grow. However, even at these two sites, numbers of razorback sucker collected and observed remains relatively low. Yet the continued presence of fish at these two sites over multiple years argues that they possess characteristics useful to razorback sucker. Both areas are complex, especially at higher flows. The site at RM 100.2 is in close proximity to a fairly large island complex that forms numerous habitat types year-round. Preliminary water quality readings taken in the main channel upstream of McElmo Creek, in McElmo Creek itself, and at the presumed spawning site, show that water quality parameters at the presumed spawning site are effected by flows from McElmo Creek just upstream (unpublished data). This may attract razorback sucker to this area of the San Juan River. More data on water quality at these three locations will be collected during 2001 sampling and the results will be presented in the 2001 report.

The reason that razorback sucker are frequently found at or near the so-called “razorback sucker backwater” near Bluff, UT (RM 77.3) is unknown. At lower flows (when many of the contacts with and collections of stocked razorback sucker have taken place), the backwater is dry and this area of the main channel would not seem to possess any special qualities that would attract razorback sucker to it as opposed to other areas of the river. As flows rise however, this site becomes a large backwater (at somewhere around 1100-1500 CFS), in fact one of the largest in the immediate area. As flows continue to rise, this backwater becomes a flow-through side channel, but because of the orientation of its upstream inflow (i.e. almost perpendicular) to the main channel, the velocities in this side channel tend to remain lower than the adjacent main channel. At times when this backwater-side channel is

inundated it does provide a habitat that is very different from the adjacent main channel.

While these two sites possess characteristics that appear to attract razorback sucker, they do not appear to be unique when compared to many other areas of the San Juan River. It seems likely that as more razorback sucker are stocked in the San Juan River and as monitoring continues, more areas such as these will be discovered.

Over two and a half times as many razorback sucker have been recaptured in the 50-RM section of the San Juan River from RM 130.0 to 80.0 as have been collected from the 50-RM section immediately upstream. Likewise, over twice as many razorback sucker have been recaptured from RM 130.0 to 80.0 as have been collected from the 80-RM section immediately downstream. It is possible that this area of the river yields more recaptures simply because this is the area where the majority of stocked fish stop displacing downstream after stocking. However, it is intriguing that such a high percentage of razorback sucker recaptures are centered around the area of the San Juan River in which both the Mancos River (RM 122.6) and McElmo Creek (RM 100.5) enter the San Juan River. These two tributaries are the two largest, most consistently-flowing tributaries to enter the San Juan River downstream of the Hogback Diversion (RM 158.6).

Movement Patterns

As was observed among razorback sucker stocked as part of the experimental stocking study, the majority of razorback sucker stocked as part of the five-year augmentation effort (and subsequently recaptured) initially moved downstream after stocking. The only two rare fishes documented to have

moved upstream past Hogback Diversion (RM 158.6) since 1991 were both small stocked fish: a 193 mm TL razorback sucker originally stocked at RM 158.6; and a 183 mm TL Colorado pikeminnow, probably originally stocked at Shiprock bridge (RM 147.9, date unknown) and recaptured on 31 August 1998 at RM 162.3 (Ryden 2000c). Like the razorback sucker, it is assumed that Hogback Diversion had been destroyed by river flows at the time of the stocked Colorado pikeminnow's upstream passage.

The continued movement of razorback sucker into Lake Powell after stocking from as far upstream as RM 158.6 is somewhat disconcerting. Razorback sucker collected in the San Juan River inflow area, were generally fish that were large (> 400 mm TL) at the time of stocking. It seems that despite stocking razorback sucker as far upstream in designated Critical Habitat as possible and trying to stock larger fish (> 350 mm TL) whenever possible, a certain number of stocked fish will inevitably end up in Lake Powell. However, as long as the waterfall that was present at RM 0.0 between the late 1980's and 1995 remains inundated and a population of razorback sucker remains in the San Juan River, there is both opportunity and motivation for these fish to move back upstream into the river.

The documented movement of three ripe adult fish to RM 100.2 in both 1997 and 1999 strongly suggests spawning at this site. This site is discussed in more detail in Chapter 3 of this report.

The majority of data collected on both radio- and PIT-tagged razorback sucker used to determine movement patterns over the last several years, indicates large initial downstream displacements after stocking. Although downstream displacements following stocking seem to be inevitable, given time at least some razorback sucker will move back upstream and colonize upstream areas.

CHAPTER 2: SURVIVAL AND GROWTH OF STOCKED RAZORBACK SUCKER

< Objective 2: Determine survival rates and growth rates of hatchery-reared, known-age razorback sucker in the wild

METHODS

Survival of stocked razorback sucker was determined from recaptured fish. Recapture rates were compared among varying size-classes of stocked razorback sucker to determine which size-classes had the highest recapture (i.e., implied survival) rates post-stocking. Schnabel and Lincoln-Petersen (using Bailey's modification for low numbers of recaptured fish) population estimates (Van den Avyle 1993) were performed for spring and fall monitoring trips, for 1995-2000, to determine the size of the razorback sucker population in the common sampled area, i.e., RM 158.6-76.4. Population estimate values were then extrapolated to "riverwide" (RM 158.6-2.9) estimates based on the population estimate value versus the mean percentage of total razorback sucker recaptures that occurred in the common sampled area (RM 158.8-76.4)of the San Juan River (i.e., 58.5%) on fall sampling trips, which sampled from RM 158.6-2.9, 1995-2000. In other words to extrapolate the Schnabel or Lincoln-Petersen estimate to the larger area:

(population estimate value/58.5)(100)= "riverwide" estimate*

Population estimate values were compared to total (i.e., juvenile + adult) catch per unit effort (CPUE) values and the assumed survival curves from the five-year augmentation plan (Ryden 1997) to determine the relative usefulness of those two metrics in estimating population size for stocked razorback sucker.

In an analysis not directly related to the specific objectives of this report, an attempt was made to use 1)numbers of recaptured fish, 2) total CPUE, and 3) population estimate values, to determine the sampling efficiency for stocked razorback sucker during razorback sucker monitoring trips (Appendix I).

Growth was determined from measurements of recaptured fish. Growth rate trends for recaptured fish stocked in distinct 10-mm total length (TL) size-class groupings were compared. Mean TL (and range) was determined for age at recapture and used to plot a growth curve for TL at age. Absolute and relative increases in TL (Van den Avyle 1993) were determined for distinct one-year growth periods.

RESULTS

Survival

Razorback sucker stocked at larger sizes (> 350 mm TL) are more frequently recaptured than are those stocked at smaller sizes (Tables 8a and 8b; Ryden 2000a, 2000c). Stockings of razorback sucker with mean TL's > 400 mm all had recapture rates of at least 6.0% with most over 10.0%, while recapture rates for stockings of razorback sucker whose mean TL was < 401 mm

Table 8a. Numbers and sizes of razorback sucker stocked into the San Juan River between 1994 and 2000 and recaptured, by year, as of 31 December 2000. Note: This table is for first-time recaptures only!

Date Stocked	Number Stocked	Mean TL at Stocking (in mm)	Number of recaptures							Percent Recaptured
			1994	1995	1996	1997	1998	1999	2000	
03/30/1994	15	277	0	0	0	1	0	0	1	13.3%
10/27/1994	16	403	0	2	0	0	0	0	0	12.5%
11/17/1994	478	190	0	3	1	0	0	0	0	0.8%
11/18/1994	177	400	0	22	11	8	3	5	3	29.4%
09/27/1995	16	424		0	3	0	0	0	0	18.8%
10/03/1996	237	335			2	1	0	1	0	1.7%
09/03/1997	1027	193				4	1	0	0	0.5%
09/17/1997	227	229				0	0	1	0	0.4%
09/19/1997	1631	185				0	2	0	1	0.2%
04/22/1998	57	420					2	3	2	12.3%
05/28/1998	67	417					0	4	0	6.0%
10/15/1998	1155	232					0	1	1	0.2%
10/20/2000	1044	214							0	0.0%
Totals	6147		0	27	17	14	8	15	8	1.4%

Table 8b. Numbers, by size class at time of stocking, of razorback sucker stocked into the San Juan River between 1994 and 2000 and recaptured as of 31 December 2000. Note: This table is for first-time recaptures only!

Total Length In Milli-meters	Of 6147 Stocked Fish		Of 89 Known-Origin Recaptures	
	Percent of Total Represented By This Size-Class	Total Number Stocked	Percent of Total Represented By This Size-Class	Total Number Caught
< 51	0.0%	0	0.0%	0
51-100	<0.1%	1	0.0%	0
101-150	7.4%	455	0.0%	0
151-200	46.3%	2848	3.4%	3
201-250	30.9%	1905	9.0%	8
251-300	2.4%	146	3.4%	3
301-350	2.9%	176	4.5%	4
351-400	6.0%	366	29.2%	26
401-450	3.8%	233	50.5%	45
451-500	0.2%	14	0.0%	0
>500	<0.1%	3	0.0%	0
Totals	100.0%	6147	100.0%	89

were, with one exception, all under 2.0% (Table 8a). Fourteen (66.7%) of the 21 razorback sucker recaptures from stockings whose mean TL was < 400 were individuals that were larger than the mean TL for that lot of stocked fish. Of the 13 razorback sucker recaptured a second time after stocking, 10 (76.9%) were from stockings with mean TL's > 400 mm. All three razorback sucker recaptured a third time after stocking came from stockings with mean TL's > 400 mm.

Fish stocked at 351-450 mm TL composed only 9.8% (n = 599) of the 6,147 razorback sucker stocked between 1994 and 2000. Yet fish in this size-class accounted for 79.8% (n = 71) of the 89 known-origin recaptures in that same time period (Table 8b). In comparison, razorback sucker stocked at < 351 mm TL composed 90.0% (n = 5,531) of the 6,147 stocked fish, yet accounted for only 20.2% (n = 18) of the 89 known-origin recaptures in that same time period (Table 8b). Very few razorback sucker over 450 mm TL (n = 17) were stocked and none were recaptured.

The Schnabel multiple census population estimate for razorback sucker recaptured from RM 158.6-76.4 estimated that 157 razorback sucker (95% confidence interval {C.I.}= 90-304 fish) were in this section of river in October 2000 (Table 9a). This same estimate yielded values that fluctuated from a low of 80 fish (95% C.I. = 14-702 fish) in October 1995 to a high of 305 fish (95% C.I. = 54-939 fish) in October 1996 (Table 9a). The Schnabel population estimate value, extrapolated, yields a value of 268 razorback sucker from RM 158.6-2.9 in October 2000 (Table 9b). Extrapolated Schnabel estimate values fluctuated from a low of 137 fish in October 1995 to a high of 521 fish in October 1996 (Table 9b).

The Lincoln-Petersen population estimate for razorback sucker recaptured from RM 158.6-76.4 estimated that 135 razorback sucker were in this section of river in May 2000 (Table 10a). This same estimate yielded values that fluctuated from a low of 48 fish in May 1995 to a high of 196 fish in May 1999

Table 9a. Schnabel multiple census population estimates for stocked razorback sucker (RM 158.6-76.4) on spring and fall standardized monitoring trips, 1995-2000.

Schnabel Population Estimates (RM 158.6-76.4):		
Trip	Schnabel Population Estimate	95% Confidence Interval (C.I.)
Oct. 1995	80	14-702
May 1996	180	32-702
Oct. 1996	305	54-939
May 1997	172	59-858
Oct. 1997	207	70-1033
May 1998	193	76-772
Oct. 1998	156	71-425
May 1999	137	74-291
Oct. 1999	151	82-322
May 2000	152	85-309
Oct. 2000	157	90-304
Total lengths (in mm) of the 12 valid razorback sucker recaptures used in the Schnabel Population Estimate = 325, 337, 370, 390, 404, 404, 408, 408, 414, 418, 422, and 428.		

Table 9b. Extrapolated riverwide (RM 158.6-2.9) population estimates for stocked razorback sucker, based on 58.5% of recaptures on October sampling trips (RM 158.6-2.9) being collected in the area covered by the Schnabel population estimate (RM 158.6-76.4), above.

Trip	Extrapolated Population Estimate (RM 158.6-2.9)
October 1995	137
October 1996	521
October 1997	354
October 1998	267
October 1999	258
October 2000	268

Table 10a. Lincoln-Petersen population estimates (using Bailey's modification) for stocked razorback sucker (RM 158.6-76.4) on spring and fall standardized monitoring trips, 1995-2000.

Lincoln-Petersen Population Estimates (RM 158.6-76.4):	
Trip	Lincoln-Petersen Population Estimate
May 1995	48
Oct. 1995	120
May 1996	150
Oct. 1996	80
May 1997	140
Oct. 1997	95
May 1998	68
Oct. 1998	95
May 1999	196
Oct. 1999	104
May 2000	135

Table 10b. Extrapolated riverwide (RM 158.6-2.9) population estimates for stocked razorback sucker, based on 58.5% of recaptures on October sampling trips (RM 158.6-2.9) being collected in the area covered by the Lincoln-Petersen population estimate (RM 158.6-76.4).

Trip	Extrapolated Population Estimate (RM 158.6-2.9)
October 1995	205
October 1996	137
October 1997	162
October 1998	162
October 1999	178

(Table 10a). Extrapolated Lincoln-Petersen estimate values fluctuated from a low of 137 fish in October 1996 to a high of 205 fish in October 1995 (Table 10b). Values for the two population estimate models do not track each other exactly. However, with on exception (i.e., May 1998), all of the Lincoln-Petersen population estimate values for RM 158.6-76.4 fit within the 95% C.I.'s for the corresponding Schnabel population estimate.

Total CPUE for razorback sucker collected on spring razorback sucker monitoring trips tended to fluctuate more than that seen on October adult fish community monitoring trips (Tables 11 and 12). In all cases, total CPUE values were well below the target value of 1.0 fish per RM specified in the five-year augmentation plan (Ryden 1997). In general, fluctuations in total CPUE did not track fluctuations in population estimates very well. The two values that track each other the best are the Lincoln-Petersen population estimate values and fish per RM values for fall trips (Tables 10a and 12). One thing that both of the population estimate models and the total CPUE values (fish/RM or fish/hour) agree on is that there are not very many razorback sucker (probably at most 300) in the river at the present time.

Table 13 represents the estimated number of stocked razorback sucker surviving at the beginning of the calendar year, 1997-2000, based on the assumed survival rates used in the five-year augmentation plan (Ryden 1997). If the Schnabel and Lincoln-Petersen population estimate models are anywhere close to correct, then the estimated survival curves from the five-year augmentation plan overestimate survival of stocked razorback sucker by 1.9-4.5 times (Tables 9a and 13) and this number increases with time (i.e., May 1999 = overestimated by 1.9 times, May 1998 = 2.1 times, May 1999 = 3.8 times, May 2000 = 4.5 times). This seems to be an indication that especially the survival values used for fish in years four through eight after stocking (i.e., .8 in years 4 and 5, .85 in year 6, and .9 in years 7 and 8 in Table 13) are too high and not indicative of real-world survival.

Table 11. Total numbers collected and CPUE for stocked razorback sucker recaptured in the San Juan River during spring razorback sucker monitoring trips (RM 158.6-76.4), 1995-2000.

Year	Number of Razorback Sucker Recaptured	Sampling Effort: Hours	Catch Per Unit Effort: Fish/Hour	Sampling Effort: River Miles (RM)	Catch Per Unit Effort: Fish/RM
1995	17	83.98	0.20	262.1	0.06
1996	3	88.76	0.03	238.3	0.01
1997	6	73.13	0.08	189.0	0.03
1998	4	81.93	0.05	245.5	0.02
1999	11	70.52	0.16	159.3	0.07
2000	3	46.71	0.06	122.6	0.02

Table 12. Total numbers collected and CPUE for stocked razorback sucker recaptured in the San Juan River during fall adult fish community monitoring trips (RM 158.6-2.9), 1995-2000.

Year	Number of Razorback Sucker Recaptured	Sampling Effort: Hours	Catch Per Unit Effort: Fish/Hour	Sampling Effort: River Miles (RM)	Catch Per Unit Effort: Fish/RM
1995	7	148.15	0.05	340.4	0.02
1996	7	155.75	0.04	376.7	0.02
1997	8	154.52	0.05	388.2	0.02
1998	8	122.00	0.07	301.8	0.03
1999	5	81.51	0.06	208.3	0.02
2000	5	106.93	0.05	261.2	0.02

Table 13. Number of stocked razorback sucker projected to have survived in subsequent years, post-stocking. These numbers are based on the survivorship estimate curves used in the five-year augmentation plan (Ryden 1997). Parenthetic numbers represent the estimated survival rate from the previous year.

Stocking Year	Number Of Fish	Survival In Year... 1 (1994)	2 (1995)	3 (1996)	4 (1997)	5 (1998)	6 (1999)	7 (2000)	8 (2001)
Experimental Stockings (1994-1996)--FYI ONLY! Not Included In Augmentation Plan Projected Numbers:									
1994	686	343(.5)	206(.6)	144(.7)	115(.8)	92(.8)	78(.85)	70(.9)	63(.9)
1995	16	----	8(.5)	5(.6)	4(.7)	3(.8)	2(.8)	2(.85)	2(.9)
1996	237	----	----	119(.5)	71(.6)	50(.7)	40(.8)	32(.8)	27(.85)
Total	939	343	214	268	190	145	120	104	92
Numbers Actually Stocked For Augmentation Plan (1997-present):									
1997	2,885	----	----	----	1,443(.5)	866(.6)	606(.7)	485(.8)	388(.8)
1998	1,279	----	----	----	----	640(.5)	384(.6)	269(.7)	215(.8)
1999	0	----	----	----	----	----	0	0	0
2000	1,044	----	----	----	----	----	----	522(.5)	313(.6)
2001	NO FISH STOCKED YET								
Total	5,208	----	----	----	1,443	1,506	990	1,276	----
Numbers Projected To Be Stocked In 1997 Augmentation Plan:									
1997	31,800	----	----	----	15,900(.5)	9,540(.6)	6,678(.7)	5,342(.8)	4,274(.8)
1998	12,720	----	----	----	----	6,360(.5)	3,816(.6)	2,671(.7)	2,137(.8)
1999	10,812	----	----	----	----	----	5,406(.5)	3,244(.6)	2,271(.7)
2000	9,286	----	----	----	----	----	----	4,643(.5)	2,786(.6)
2001	8,864	----	----	----	----	----	----	----	4,432(.5)
Total	73,482				15,900	15,900	15,900	15,900	15,900
Projected Shortfall		----	----	----	14,457	14,394	14,910	14,624	None Yet

Growth

Razorback sucker have been stocked at many different size-classes and growth of these fish have varied widely (Table 14 and Figure 7). As was observed in past years, razorback sucker stocked at < 351 mm TL grew twice as fast (0.11 mm/day versus 0.05 mm/day) as those stocked at > 350 mm TL (Table 14, Figure 7). The fastest growth rates were observed in fish stocked between 251 and 270 mm TL (Table 14). However, sample sizes used for determining growth in most 10-mm size-classes are still very small. Known female razorback sucker (n = 21) increased in TL almost twice as fast (0.07 mm/day versus 0.04 mm/day) as did known males (n = 48; Table 14).

Growth curves developed for razorback sucker show that between age-0 and age-4 razorback sucker grow rapidly reaching a mean TL of 438 mm (range = 348-508 mm TL) at age-4 (Figure 8). After age-4, the growth curve flattens considerably and gains in TL between years become much less dramatic (Figure 8). There is a considerable range for TL values at several ages (Figure 8). This reflects the wide range of sizes among razorback sucker of the same age from different hatchery facilities used in stocking efforts. The largest gains in TL relative to the fish's body size occur from age-1 to age-2 and from age-2 to age-3, when razorback sucker increase in TL by 29.6% and 44.7%, respectively (Figure 9). This translates into an average increase of 63 mm TL and 123 mm TL, respectively (Figure 9). By age-7 stocked razorback sucker demonstrated almost no increase in TL between years (Figures 8 and 9).

Table 14. Growth of razorback sucker, in millimeters per day (mm/day), observed during 105 recapture events, including multiple recaptures, 1994-2000.

Total Length Range (In Millimeters) Of Recaptured Fish At Time Of Stocking	Growth (mm/day)	Number Of Recapture Events Growth Rates Are Based On (n =)
By 10-mm TL Size Classes:		
<221	0.10	5
221-230	0.12	2
231-240	0.12	4
241-250	No Data	No Data
251-260	0.20	2
261-270	0.22	1
271-280	0.08	1
281-290	No Data	No Data
291-300	No Data	No Data
301-310	No Data	No Data
311-320	No Data	No Data
321-330	0.10	2
331-340	0.05	2
341-350	0.04	2
351-360	0.08	1
361-370	0.05	4
371-380	0.03	2
381-390	0.03	8
391-400	0.05	13
401-410	0.05	21
411-420	0.04	16
421-430	0.04	12
431-440	0.08	2
441-450	0.06	5
>450	No Data	No Data
Small Versus Large Fish:		
<351 mm TL (range = 193-348)	0.11	21
>350 mm TL (range = 356-445)	0.05	84
Females Versus Males:		
Known Females (range = 229-442 mm TL)	0.07	21
Known Males (range = 232-445 mm TL)	0.04	48

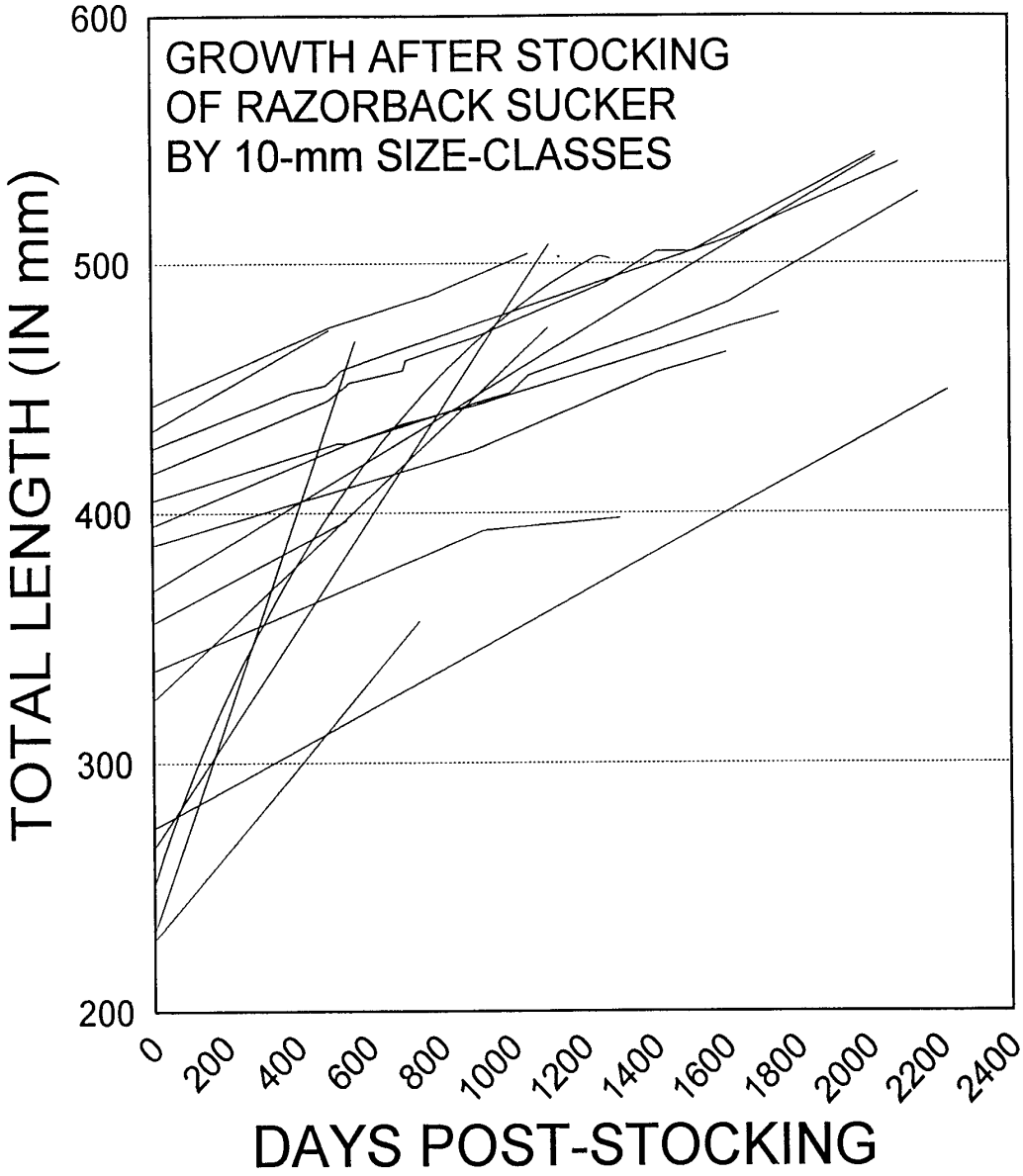
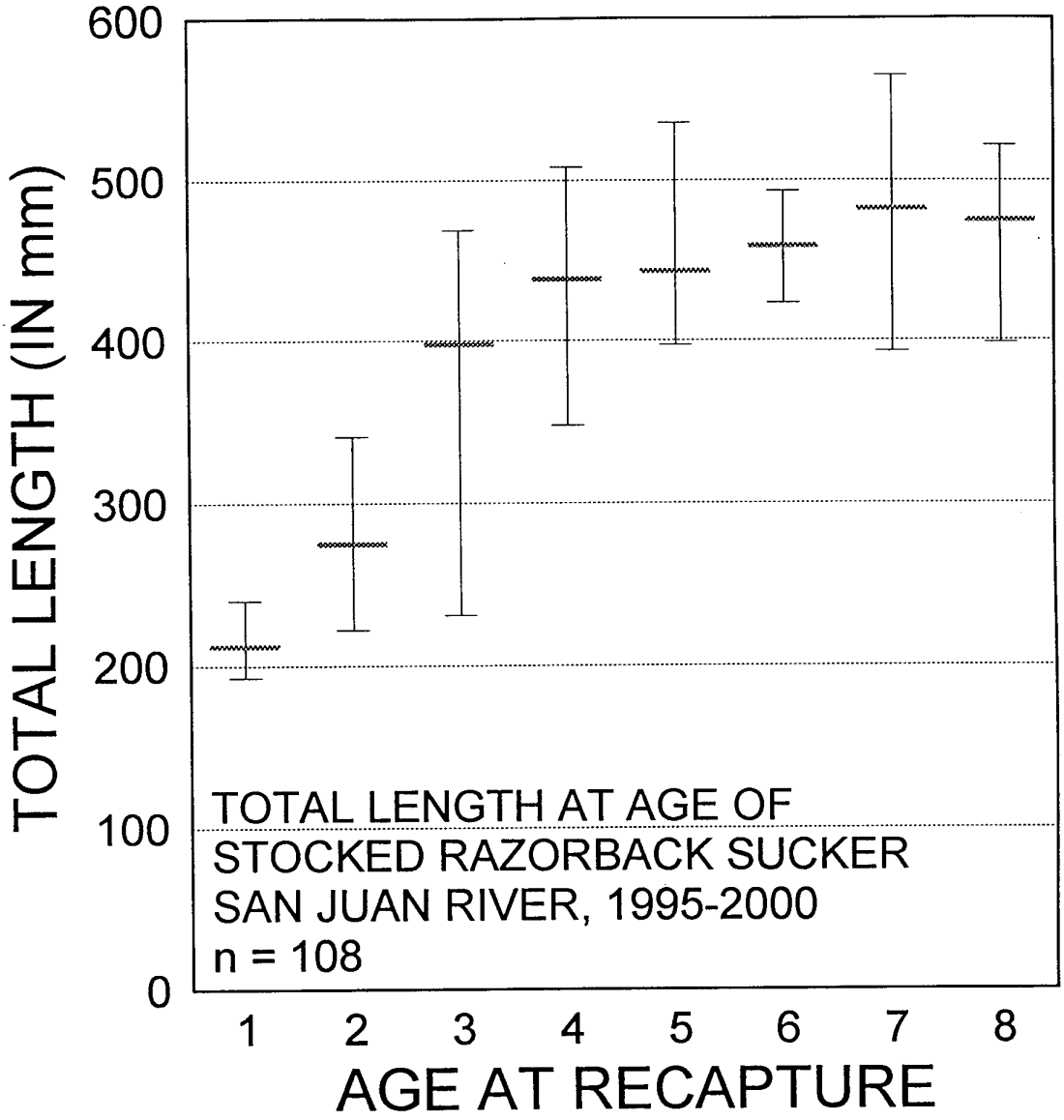


Figure 7. Growth after stocking of razorback sucker, 1994-2000. Each line represents the mean growth of all recaptured razorback sucker stocked within the same 10-mm size-class.



ıre 8. Total length at age observed for 108 recaptured razorback sucker in the San Juan River, 1995-2000. The dark horizontal lines represent mean values, while the error bars represent the range of values observed among recaptured fish.

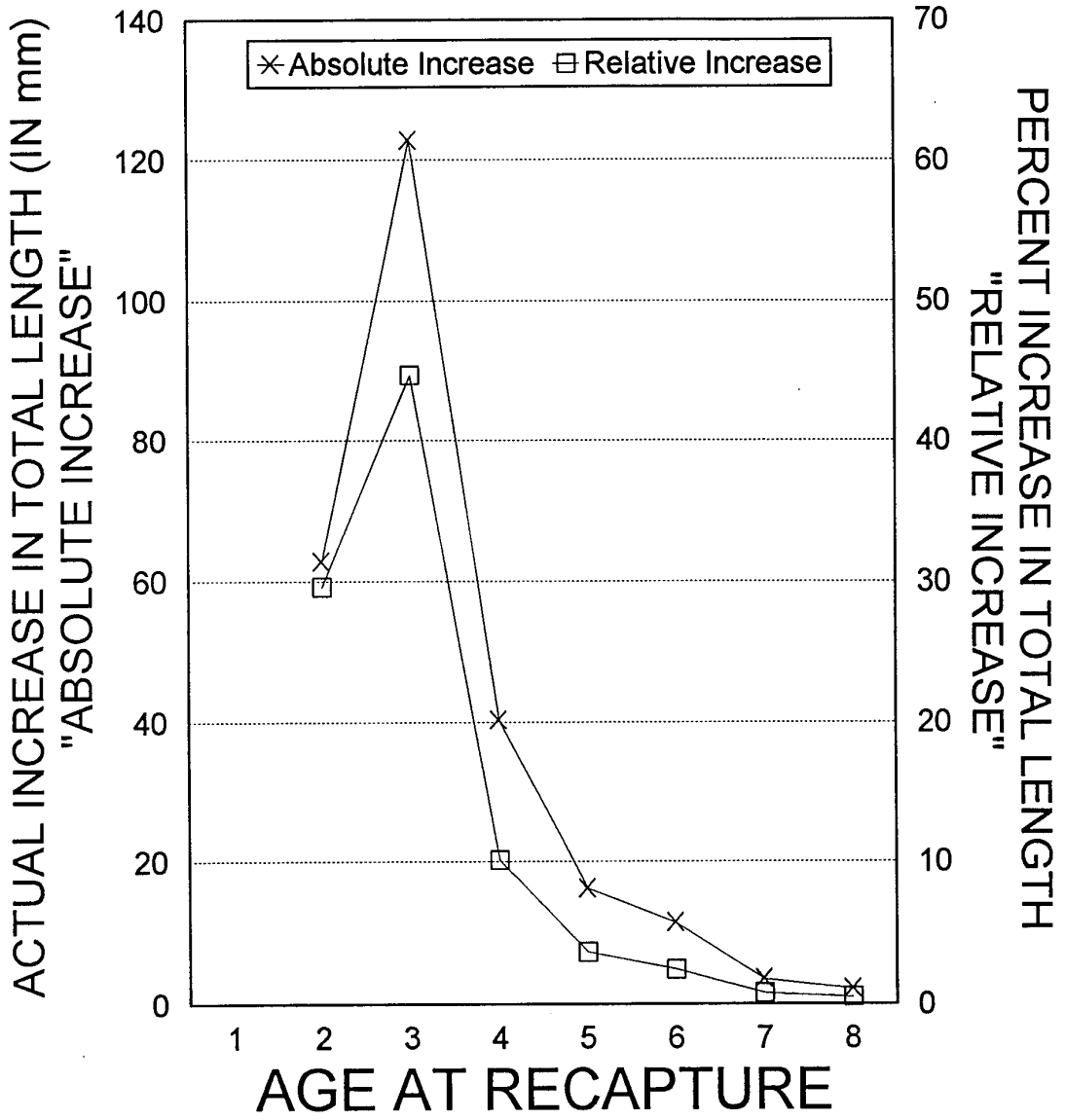


Figure 9. Absolute and relative increases in total length at age observed among 108 recaptured razorback sucker in the San Juan River, 1995-2000. NOTE: Markers at age-2 indicate the increase in total length from age-1 to age-2, those at age-3 indicate growth from age-2 to age-3, and so on.

DISCUSSION

Survival

Overall, survival of razorback sucker stocked into the San Juan River between 1994 and 2000 appears to be quite good compared to other stocking efforts attempted in the Lower Colorado River Basin (LCRB) and the Gunnison and Colorado Rivers. Stocking of small size-class (range = 45-168 mm SL) razorback sucker in the LCRB in the presence of ictalurid predators (flathead catfish [Pylodictis olivaris] and channel catfish) was unsuccessful (Marsh and Brooks 1989). Marsh and Brooks (1989) stated that the loss of stocked razorback sucker to predation lessened when average size of stocked fish was increased from 68 to 113 mm SL. In addition, Marsh and Brooks (1989) theorized that stocking razorback sucker in the range of 300 mm may enhance post-stocking survival. Conversely, adult razorback sucker collected from "Etter Pond" (near DeBeque, CO) and stocked into the Gunnison and Colorado Rivers upstream of Grand Junction, CO in 1994 and 1995 demonstrated poor survival with mortality rates being as high as 85% in the Colorado and 88% in Gunnison River (Burdick and Bonar 1997). High degrees of body fat in stocked fish were reported, indicating that the "Etter Pond" razorback sucker were in good condition at the time of radio tag implantation and stocking. Burdick and Bonar (1997) speculated that the reasons for poor survival of these adults may have been due to inability to cope with the riverine environment (i.e., currents, turbidity, and fluctuating flows), or being unable to learn to use natural food items, thus leading to eventual starvation. These older fish (possibly as old as 11-12 years old at the time of stocking) may simply have been too domesticated to their artificial pond environment to be able to

survive in a riverine environment, a situation known as domestication selection (Burdick 1992, Ryden and Pfeifer 1994a). However, the additional stress associated with radio tag implantation and immediate stocking in a riverine environment without being allowed to recover first, may also have been a major factor in the failure of these stocked fish to survive. Razorback sucker stocked into the San Juan River between 1994 and 2000 were apparently still young enough to not be domesticated, but large enough, in many cases, to avoid predation by channel catfish and other predators (i.e., walleye and striped bass). A bite mark from a channel catfish observed on a recaptured, PIT-tagged razorback sucker (408 mm TL) provides circumstantial evidence of aggression towards if not attempted predation upon stocked razorback sucker (Ryden 2000c). That observation combined with the documented predation upon sympatric flannelmouth sucker (Catostomus latipinnis), some as large as 300 mm SL (Brooks et al. 2000), by nonnative walleye (Stizostedion vitreum), striped bass (Morone saxitilis), and channel catfish, and the documented predation upon young stocked razorback sucker by ictalurids in the LCRB (Marsh and Brooks 1989) suggests that nonnative predators in the San Juan River may have a major impact on stocked razorback sucker of 410 mm TL or less. Stocking fish at 410 mm TL or greater appears to get fish past the predation threshold, as well as getting them in the river at an age where they are likely to spawn soon after stocking.

Despite the comparative success of razorback sucker stocked into the San Juan River versus other rivers, the fish stocked as part of the five-year augmentation effort (1997-2001), though more than four times as numerous as those stocked during the experimental stocking study (1994-1996), are being recaptured in smaller numbers than their predecessors. The likely reason for this is their relative size at time of stocking. Over seven years of sampling, razorback sucker stocked at < 351 mm TL are recaptured much less frequently than razorback sucker stocked at > 350 mm TL. Some of the

difference observed between recaptures of various size-class razorback sucker after stocking can almost certainly be placed on the tendency (i.e., sampling bias) of electrofishing to collect larger size-classes of fish. However, between 1991 and 1997 main channel adult fish community monitoring studies (electrofishing) were very successful in collecting smaller size-class (< 351 mm TL) flannelmouth sucker, bluehead sucker, and channel catfish, as well as numerous adult speckled dace and red shiner, which reach a maximum of about 150 mm TL as adults (e.g., Ryden 2000b). In addition, intensive seining efforts between 1994 and 1999 by the New Mexico Department of Game and Fish and the Utah Division of Wildlife Resources, and sporadic seining, trammel-netting, and hoop-netting efforts by other agencies resulted in the collection of only a very few small size-class razorback sucker. In addition, given the growth curve presented in this report (Figure 8), even small razorback sucker stocked between 1994 and 1997 should have been $\geq$ 400 mm TL by the 2000 and 2001 sampling seasons, making them vulnerable to electrofishing. If razorback sucker stocked at smaller size-classes had survived in anywhere close to the same numbers as those stocked at larger sizes, our razorback sucker collections should now be dominated by them, given their numerical superiority.

It is recommended that the SJRIP make as much of an effort as possible to hold razorback sucker in grow-out ponds until they reach at least 350 mm TL, or more preferably 400 mm TL. This will likely require fish to be held for at least two growing seasons before stocking. Although the ultimate goal of the SJRIP is to establish self-sustaining populations of razorback sucker in the San Juan River, the immediate goal of the five-year augmentation effort is to get a population of adult fish into the river. It is felt that this can best be achieved by stocking razorback sucker > 350 mm TL.

Growth

The faster growth rates observed in razorback sucker stocked at < 351 mm TL were expected. Most species of fish exhibit a period of rapid growth early in life and a subsequent period of more gradual increases as they mature (Van den Avyle 1993). Minckley (1983) indicated that, based on size-frequency distributions of wild-caught fish, growth among “adult” razorback sucker (370-740 mm TL) in Lake Mohave averaged only about 5 mm per year. However, a slow down in growth consistent with that reported by Minckley (1983) was not apparent in our stocked fish until at least age 7, when fish had reached a mean TL of about 480 mm.

The growth curve developed for stocked razorback sucker (Figure 8) acts as a tool to judge the relative age of untagged razorback sucker. Currently, no wild razorback sucker (other than larvae being collected by crews from UNM) are being collected in the San Juan River. However, if progeny of stocked fish successfully recruit, this growth curve will provide a tool to make an educated guess as to their age.

CHAPTER 3: WILL HATCHERY-REARED RAZORBACK SUCKER SPAWN IN THE WILD?

< Objective 3: Determine whether hatchery-reared razorback sucker will recruit into the adult population and successfully spawn in the wild

METHODS

Recaptured razorback sucker were examined to determine reproductive status and age (via PIT tag number). Those fish that were actively expressing gametes (i.e., male = 'ripe,' female = 'gravid') or had visible tuberculation present were considered to be mature, sexually active fish. Aggregations of three or more ripe adult razorback sucker during the spawning season were considered to be possible spawning aggregations, especially if both ripe male and gravid female razorback sucker were present or if a particular site was found to have aggregations of ripe or gravid adult fish in more than one year.

RESULTS

Of the 122 recapture events (including second- and third-time recaptures, unknown origin fish {no PIT tag read}, and the fish that were stocked in Lake Powell) between May 1995 and December 2000, 51 were males, 21 were females, and 50 were of indeterminate sex. Of the 21 identified females (357-565 mm TL

at time of recapture), only two were obviously gravid (i.e., freely expressing eggs). Both of these gravid females were collected on 16 April 1999, one at RM 108.0 (548 mm TL), and one at RM 100.2 (565 mm TL). None of the other 19 razorback sucker identified as females (357-527 mm TL), collected between 13 April and 24 October (RM 141.0-55.3), were obviously gravid. Of the 51 known males (376-522 mm TL; including three unknown-origin fish), 45 were tuberculate (376-522 mm TL), 23 of which were ripe (376-509 mm TL). These 23 ripe males were collected between 16 March and 2 October, from RM 140.0 to RM -8.5 in Lake Powell. Five (21.7%) of the 23 ripe, tuberculate males were collected at RM 100.2 (i.e., the suspected spawning site), three on 3 May 1997 and two on 16 April 1999. The 22 tuberculate males that were not ripe (388-522 mm TL) were collected between 27 April and 22 October, from RM 156.5-0.0. The other six identified males (423-505 mm TL) that were neither tuberculate or ripe were collected between 6 June and 7 October, from RM 77.5 to RM -4.1 in Lake Powell.

1997

On 3 May 1997, a probable spawning aggregation of razorback sucker was identified at RM 100.2 (Ryden 2000a). This aggregation consisted of three ripe males (412-456 mm TL) that were collected in a single dip net and three additional razorback sucker that were observed but not collected. All six of these fish were within a 10 ft^2 area, in less than three feet of water, within ten feet of the river right shoreline, over a shoreline cobble shoal/run (Figure 3; Ryden 2000a). A fourth ripe, male razorback sucker (397 mm TL) was collected 0.3 RM upstream of this aggregation, also on river right, a few meters downstream of the McElmo Creek confluence at RM 100.5 (Figure 3;

Ryden 2000a). Of the four male razorback sucker that were recaptured at RM 100.5 and 100.2, three had originally been stocked at either Hogback Diversion (RM 158.6) or Bluff, UT (RM 79.6), and had converged near Aneth presumably to spawn (Figure 10; Ryden 2000a). A PIT tag number was not determined for one fish collected at RM 100.2, as the PIT tag reader quit working. Therefore a stocking location for the last fish could not be determined. The ripe male razorback sucker that was recaptured at RM 100.5 was a radio-tagged fish that had been located at RM 129.9 in February 1997 and was located just downstream of suspected spawning site at RM 100.0 on 15 May 1997 (Figure 3; Ryden 2000a). One of the three males captured at RM 100.2 was also a radio-tagged fish that was previously contacted at RM 93.8 on 22 October 1996 (Figure 10; Ryden 2000a). The three ripe males collected at RM 100.2 were collected in a large group of ripe adult, presumably spawning, flannelmouth sucker (Ryden 2000a). Flows were increasing in the river during the time these electrofishing collections were made, indicating that these razorback sucker were spawning on the ascending limb of the hydrograph as is seen in other Upper Colorado River Basin (UCRB) rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998). Flows at the Shiprock, NM USGS gage on 15 April 1997 were 1,390; 1,770 on 3 May; 5,580 on 15 May; and 8,050 on 31 May 1997 (Ryden 2000a).

1998

No obviously ripe or gravid razorback sucker were collected during the May 1998 razorback sucker monitoring trip. Nor were any aggregations of two or more razorback sucker identified on this trip. However, based on the observations of suspected spawning razorback sucker in May 1997, crews from the University of New Mexico (UNM) began intensive monitoring efforts (light-

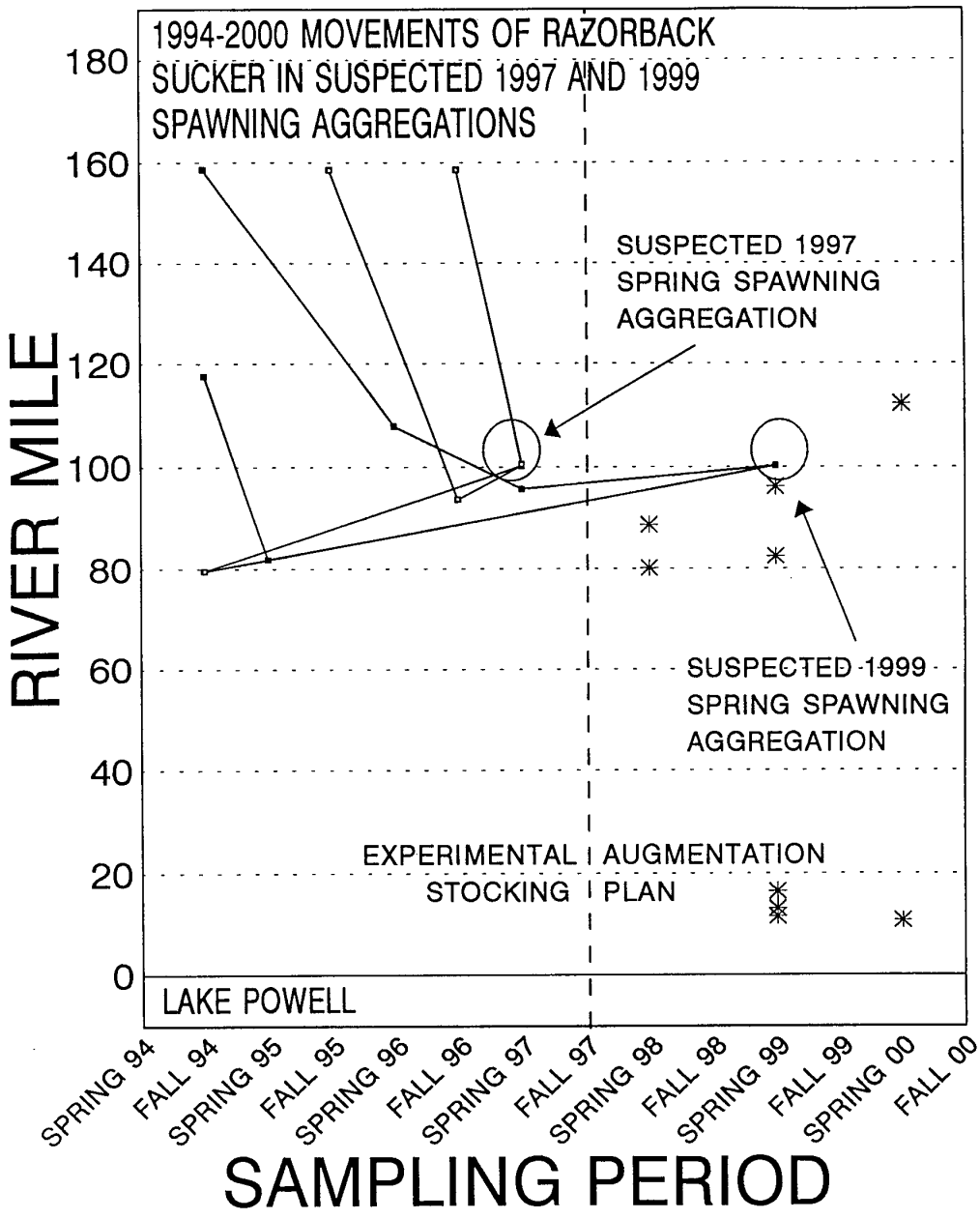


Figure 10. Evidence for suspected razorback sucker spawning activities in the San Juan River between 1997 and 2000. Solid lines represent the movements of ripe adult fish to RM 100.2 in 1997 and 1999, while asterisks represent the locations at which larval razorback sucker were collected in spring 1998 and 1999, and appear to have been collected again in 2000 (S. Platania pers. comm.).

trapping and seining for larval fishes) throughout the San Juan River in the spring of 1998 to try to document razorback sucker reproduction (S. Platania, pers. comm.). On 21 and 22 May 1998, two larval razorback sucker (flexion mesolarvae = 12.7 mm TL and 12.1 mm TL, respectively) were collected in seines from backwaters between Montezuma Creek and Bluff, UT (RM 88.8 and 80.2, respectively; S. Platania pers. comm.; Figure 10). Platania stated that the "mesohabitat location where these fish were collected indicates that they were no longer true components of the drift (i.e., these specimens had the ability to move out of the flow)." Flows at the Shiprock, NM gage during this general time frame in 1998 were 1,170 on 15 April 1998; 3,500 on 1 May; 5,190 on 15 May; and 7,370 on 31 May 1998 (Ryden 2000a). This again indicated that razorback sucker were spawning on the ascending limb of the hydrograph.

1999

On 16 April 1999 two ripe male razorback sucker (438 and 509 mm TL) and one gravid female (565 mm TL) razorback sucker were collected at RM 100.2 within a few feet of where the three razorback sucker were collected on 3 May 1997 (Figure 3; Ryden 2000c). These three razorback sucker were collected in the midst of numerous ripe adult, presumably spawning, flannelmouth sucker, over an embedded cobble substrate (cobble shoal/run habitat), approximately 5-10 feet from the river right bank in about 2-3 feet of water. These three fish, all stocked on 18 November 1994, had come from three different stocking sites (RM 158.6, 177.5, and 79.6; Figure 10). Flows at the Shiprock, NM USGS gage on 1 April 1999 were 1030 CFS; 1010 CFS on 16 April; 1940 on 1 May; and 2590 on 15 May 1999. As in May 1997, the increasing flows in the river during the general time frame in which these electrofishing collections were made,

indicates that these razorback sucker were spawning on the ascending limb of the hydrograph as is seen in other Upper Colorado River Basin (UCRB) rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998).

In spring 1999, crews from UNM again intensively sampled (30 light-trap samples and 144 seine samples) throughout the San Juan River to try to document razorback sucker reproduction (S. Platania, pers. comm.). Between 4 May and 14 June 1999 they collected seven larval razorback sucker, with the most upstream collection being at RM 96.2 (12 May 1999) and the most downstream at RM 11.5 (14 June 1999; S. Platania, pers. comm.; Figure 7). These seven larvae ranged in size from 10.2-20.7 mm TL and in developmental stage from protolarvae to metalarvae (S. Platania, pers. comm.). Two larvae were collected in light traps on 12 May 1999, and the other five were collected via seine (S. Platania, pers. comm.). As was the case with larval razorback sucker collected in spring 1998, the seven larvae collected in spring 1999 were all collected downstream of the suspected spawning site at RM 100.2 (Figure 10).

2000

In 2000, no razorback sucker were collected at or near RM 100.2 during spring sampling. However, two adult razorback sucker, one male (510 mm TL) and one female (508 mm TL), were collected at RM 100.05 on 3 October 2000, they were implanted with radio tags and released. These two adult fish were contacted at RM 100.2 on 23 January 2001, within a few yards of where the aggregations of razorback sucker were collected in spring 1997 and 1999.

In spring 2000, crews from UNM again intensively sampled throughout the San Juan River to try to document razorback sucker reproduction (S. Platania,

pers. comm.). On 13 and 17 June 2000, UNM crews collected what are suspected to be two larval razorback sucker at RM 112.1 and RM 10.7, respectively (S. Platania, pers. comm.; Figure 10). Preliminary identification of these two larval fish by UNM personnel indicates that they are razorback sucker, but they have been sent to the Larval Fish Laboratory at Colorado State University (i.e., to Darrel Snyder) in Fort Collins, CO for final verification. If these two larval fish are indeed razorback sucker, this would make the third straight year in which successful spawning efforts by stocked razorback sucker in the San Juan River have been documented. Unlike the previous three years however, one of the suspected larval razorback sucker was collected upstream of the suspected spawning area at RM 100.2 (Figure 10). If the larval fish collected at RM 112.1 on 13 June 2000, is indeed a razorback sucker it would mean that razorback sucker successfully spawned somewhere upstream of RM 112.1 in 2000.

DISCUSSION

Razorback sucker successfully spawned in the wild in 1998, 1999, and probably 2000, as is evidenced by Platania's collections of larval fish. A suspected spawning area has been identified at RM 100.2, just downstream of Aneth, Utah. Numerous pieces of evidence argue to this site being a razorback sucker spawning site. First, the collection of three ripe fish at this exact same location in both 1997 and again in 1999 points to a repeated use of this area by groups of razorback sucker over several years. The close proximity of the collected individuals, presence of other identified razorback sucker (seen but not collected), and collection of larval razorback sucker downstream of this site in 1998, 1999, and probably 2000 strongly suggest spawning at this

site. The collection of a probable razorback sucker larvae at RM 112.1 in June 2000 would also indicate that razorback sucker are spawning in at least one other location in the San Juan River. The tendency of razorback sucker to aggregate with flannelmouth sucker while spawning has been documented in other UCRB rivers (e.g., Tyus and Karp 1990). This intermingling of spawning adults may lead to hybridization between these two species in the wild (e.g., Buth et al. 1987).

The collection of larval razorback sucker in May 1998, April-June 1999, and probable larvae in June 2000, as well as the aggregations of presumably spawning razorback sucker at RM 100.2 in May 1997 and April 1999 prove that stocked razorback sucker are successfully locating one another, locating suitable habitats, and successfully spawning in the San Juan River. In addition, larval razorback sucker spawned at some point upstream of RM 96.2 are able to successfully move out of main channel flows and into low-velocity habitats before entering Lake Powell. The collection of aggregations of ripe adult or larval razorback sucker indicates that for the last three to four consecutive years adult razorback sucker have aggregated and spawned on the ascending limb of the hydrograph.

FY-2001 FIELD ACTIVITIES

Field activities in 2001 will include two razorback sucker monitoring (electrofishing) trips, one in late April or early May and another in mid- to late July. In addition, five adult razorback sucker (3 males, 1 female, and 1 of indeterminate sex) that were implanted with radio transmitters (tags) in October 2000 will be tracked from March through June to attempt to identify spawning behavior and habitats. Up to six adult razorback sucker (> 400 mm TL) collected on the October 2001 sub-adult and adult large-bodied fishes monitoring trip will also be implanted with radio tags for another year of tracking during spawning season (i.e., spring 2002).

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APPENDIX I.

INTRODUCTION

The following analyses are an attempt to relate various San Juan River population estimators to an estimate of relative sampling efficiency. Questions have been raised about how catch per unit effort (CPUE) values for a given species relate to actual numbers of fish in the river. To be able to relate CPUE vales to actual population numbers, one must have an idea of what the sampling efficiency for a given gear type and method of collection are.

Initial attempts to relate CPUE to actual population numbers have been attempted by Miller Ecological Consultants (Bill Miller) of Fort Collins, CO and Ecosystems Research Institute (Vince Lamarra), of Logan, UT. Their methodology includes blocking off a section of main channel habitat with nets, then repeatedly sampling it from top to bottom via electrofishing, removing all fish that are caught, and measuring the rate at which this depletion of fish from the sample area diminishes with each electrofishing pass. The first electrofishing pass in this test section of river is analogous to the one-RM electrofishing samples on adult and juvenile large-bodied fish monitoring trips, performed by the U. S. Fish and Wildlife Service (USFWS) each fall to track population trends among main channel fish species. Initial estimates obtained using this depletion sampling estimate, that on average, USFWS fall electrofishing collects 20% of the fish in any given RM. This data is still preliminary and subject to change, however, if the 20% value holds true, it could be an invaluable tool in converting sampling numbers into real population numbers.

The fact that the San Juan River razorback sucker population is made up exclusively of known quantities (at stocking) of individually-marked fish provides a unique opportunity to examine the question of CPUE versus population size to determine sampling efficiency. It also provides an

opportunity to address several pertinent questions, such as: 1) Is sampling efficiency for rare fish species (i.e., razorback sucker and Colorado pikeminnow) higher or lower than that observed for common species (i.e., flannelmouth sucker, bluehead sucker, channel catfish, and common carp)?; and 2) Is sampling efficiency for different size-classes of fish the same or different using electrofishing.

METHODS

Three methods by which measured population parameters could be related to assumed sampling efficiency were examined. The first method was to compare actual numbers to one another. In other words, assuming no mortality, actual numbers of recaptured razorback sucker when compared to actual numbers stocked should yield a straight sampling efficiency percentage. This particular analysis was performed for the various size-classes of razorback sucker to determine if a difference in sampling efficiency related to size. The second method was to compare a population estimate to actual numbers of recaptures to determine sampling efficiency. With this method there can be mortality after stocking, however, sampling effort must be very close to the same between sampling periods in order for the actual number of recaptures to be an accurate gage of sampling efficiency. The third method was to compare a population estimate to a measured CPUE value (in this case, fish/RM). Using this method, there can be mortality among stocked fish and differences in sampling effort between sampling periods are accounted for.

RESULTS

Method 1--Compare Actual Numbers Stocked To Actual Numbers of Recaptures

A difference in sampling efficiency was noted for various size-classes of razorback sucker with fish stocked at larger sizes being recaptured more frequently than fish stocked at smaller sizes, in relation to numbers stocked (Table I-1.). Razorback sucker stocked at > 400 mm TL, the least numerous size-class stocked (n = 228), had by far the highest probability of being recaptured with a sampling efficiency of $\geq$ 7.9%. This was 197.5 times higher than the $\geq$ 0.04% sampling efficiency observed for fish stocked at 101-200 mm TL, the most numerous size-class stocked (n = 2544). The considerably lower sampling efficiency values observed for smaller stocked razorback sucker are likely reflective of a high mortality rate among smaller stocked fish, a factor not quantified or accounted for in this method of analysis.

This analysis yielded fairly low sampling efficiency values for all size-classes of razorback sucker (i.e., minimum values were all less than 10% efficiency), with a mean for all size-classes combined of $\geq$ 0.6% (Table I-1). Sampling efficiency for all size-classes dropped off in years 2-6. Again, this was likely due to mortality among stocked fish.

Table I-1. Numbers of recaptures indicating survival among different size-classes of stocked razorback sucker during spring (RM 158.6-76.4) and fall (RM 158.6-53.0) standardized razorback sucker monitoring, 1995-2000 (n = 73 recaptures). Only fish recaptured after at least one overwintering period were included in this analysis.

			Number of Razorback Sucker Recaptured In Successive Years After Stocking (i.e., Number Of Overwintering Periods)					
Total Length (in mm) When Stocked	Number Of Fish Stocked	Based On Year 1 Recaptures, Sampling Efficiency For This Size Class Is	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
< 101	1	≥ 0.0%	0	0	0	0	0	0
101-200	2544	≥ 0.04%	1	0	0	0	0	0
201-300	1978	≥ 0.15%	3	2	2	0	0	1
301-400	352	≥ 2.6%	9	2	6	3	5	2
> 400	228	≥ 7.9%	18	8	3	4	4	0
All Fish	5103	≥ 0.6%	31	12	11	7	9	3

Method 2--Compare Population Estimate Values To Actual Numbers Of Recaptures

For the Schnabel population estimate versus numbers of actual recaptures, sampling efficiency was again low, ranging from a low of 1.4% to a high of 7.3% for estimate values (Table I-2). For the 95% C.I.'s surrounding the estimate values, sampling efficiencies ranged from a low of 0.3% to a high of 35.7%. This 35.7% sampling efficiency value is very high compared to all other values obtained by this analysis for the Schnabel estimate. This high value (35.7%) is a function of a relatively high number of recaptures (n = 5) compared to a relatively small population estimate range value (n = 14) for October 1995 (Table I-2). If this value were to be considered an outlier and removed from the analysis, the 95% C.I. sampling efficiency range would drop to 0.3-15.6%.

When this same analysis is repeated for the Lincoln-Petersen population estimate versus numbers of actual recaptures, a very similar trend in sampling efficiency was observed. In all cases but one, sampling efficiency was low, being less than 10% (Table I-3). The one exception was again the first value obtained for 1995, this time in May, 33.3% (Table I-3). Again this 33.3% sampling efficiency value is very high compared to all other values obtained by this analysis for the Lincoln-Petersen estimate and is a function of a relatively high number of recaptures (n = 16) compared to a relatively small population estimate value (n = 48) for October 1995 (Table I-2). If this value is considered an outlier and removed from the analysis, the sampling efficiency range would drop to 2.2-6.3% (Table I-3).

Table I-2. Schnabel multiple census population estimates for stocked razorback sucker (RM 158.6-76.4) in spring and fall standardized monitoring trips, 1995-2000.

Schnabel Population Estimates (RM 158.6-76.4):					
Trip	Schnabel Population Estimate	95% Confidence Interval (C.I.)	Actual Number Of Recaptures	Sampling Efficiency (Recaptures vs. Population Estimate)	Sampling Efficiency Ranges (Recaptures vs. 95% C.I.'s)
Oct. 1995	80	14-702	5	6.3%	0.7-35.7%
May 1996	180	32-702	5	2.8%	0.7-15.6%
Oct. 1996	305	54-939	5	1.4%	0.5-9.3%
May 1997	172	59-858	7	4.1%	0.8-11.9%
Oct. 1997	207	70-1033	3	1.4%	0.3-4.3%
May 1998	193	76-772	4	2.1%	0.5-5.3%
Oct. 1998	156	71-425	4	2.6%	0.9-5.6%
May 1999	137	74-291	10	7.3%	3.4-13.5%
Oct. 1999	151	82-322	3	2.0%	0.9-3.7%
May 2000	152	85-309	3	2.0%	1.0-3.5%
Oct. 2000	157	90-304	4	2.5%	1.3-4.4%
Total lengths (in mm) of the 12 valid razorback sucker recaptures used in the Schnabel Population Estimate = 325, 337, 370, 390, 404, 404, 408, 408, 414, 418, 422, and 428.					

Table I-3. Lincoln-Petersen population estimates (using Bailey's modification) for stocked razorback sucker (RM 158.6-76.4) in spring and fall standardized monitoring trips, 1995-2000.

Lincoln-Petersen Population Estimates (RM 158.6-76.4):			
Trip	Lincoln-Petersen Population Estimate	Actual Number Of Recaptures	Sampling Efficiency (Recaptures vs. Population Estimate)
May 1995	48	16	33.3%
Oct. 1995	120	5	4.2%
May 1996	150	5	3.3%
Oct. 1996	80	5	6.3%
May 1997	140	7	5.0%
Oct. 1997	95	3	3.2%
May 1998	68	4	5.9%
Oct. 1998	95	4	4.2%
May 1999	196	10	5.1%
Oct. 1999	104	3	2.9%
May 2000	135	3	2.2%

Method 3--Compare Population Estimate Values To CPUE Values

Comparison of Schnabel and Lincoln-Petersen population estimate values to spring monitoring CPUE (fish per RM) values yielded low sampling efficiency values ranging from 0.5-4.2% for the Schnabel estimate analysis and 0.5-10.3% for the Lincoln-Petersen estimate analysis (Table I-4). The 10.3% sampling efficiency for the Lincoln-Petersen estimate analysis in spring 1995 is again very high compared to all other values obtained by this analysis for the Lincoln-Petersen estimate. If this value is considered an outlier and removed from the analysis, the sampling efficiency range for the spring Lincoln-Petersen estimate values versus CPUE would drop to 0.5-2.9%.

As with spring monitoring, comparison of Schnabel and Lincoln-Petersen population estimate values to fall monitoring CPUE (fish per RM) values also yielded low sampling efficiency values ranging from 0.6-2.3% for the Schnabel estimate analysis and 1.4-2.9% for the Lincoln-Petersen estimate analysis (Table I-5). Unlike the spring monitoring analysis, no markedly higher sampling efficiency value was evident in the fall monitoring analysis.

Table I-4. A comparison of catch per unit effort (CPUE) for razorback sucker collected on spring razorback sucker monitoring trips (RM 158.6-76.4 = 82.2 total RM) to actual population estimate values (taken from tables 9a and 10a) for determining sampling efficiency.

Year	CPUE: fish per hour (fph)	CPUE: fish per RM (fpm)	CPUE ratio fph:fpm	Schnabel Estimate (N_S)	Number of razorback sucker per RM based on Schanbel Estimate: $N_S \div 82.2$ (N_S/RM)	Sampling Efficiency fpm ÷ (N_S/RM)	Lincoln-Petersen Estimate (N_{L-P})	Number of razorback sucker per RM based on Lincoln-Petersen Estimate: $N_{L-P} \div 82.2$ (N_{L-P}/RM)	Sampling Efficiency fpm ÷ (N_{L-P}/RM)
1995	0.20	0.06	3.3:1	N/A	N/A	N/A	48	0.58	10.3%
1996	0.03	0.01	3.0:1	180	2.19	0.5%	150	1.82	0.5%
1997	0.08	0.03	2.7:1	172	2.09	1.4%	140	1.70	1.8%
1998	0.05	0.02	2.5:1	193	2.35	0.9%	68	0.83	2.4%
1999	0.16	0.07	2.3:1	137	1.67	4.2%	196	2.38	2.9%
2000	0.06	0.02	3.0:1	152	1.85	1.1%	135	1.64	1.2%

Table I-5. A comparison of catch per unit effort (CPUE) for razorback sucker collected on fall adult fish community monitoring trips (RM 158.6-2.9 = 155.7 total RM) to extrapolated population estimate values (taken from tables 9b and 10b) for determining sampling efficiency.

Year	CPUE: fish per hour (fph)	CPUE: fish per RM (fpm)	CPUE ratio fph:fpm	Schnabel Estimate (N_S)	Number of razorback sucker per RM based on Schanbel Estimate: $N_S \div 155.7$ (N_S/RM)	Sampling Efficiency fpm ÷ (N_S/RM)	Lincoln-Petersen Estimate (N_{L-P})	Number of razorback sucker per RM based on Lincoln-Petersen Estimate: $N_{L-P} \div 155.7$ (N_{L-P}/RM)	Sampling Efficiency fpm ÷ (N_{L-P}/RM)
1995	0.05	0.02	2.5:1	137	0.88	2.3%	205	1.32	1.5%
1996	0.04	0.02	2.0:1	521	3.35	0.6%	137	0.88	2.3%
1997	0.05	0.02	2.5:1	354	2.27	0.9%	162	1.04	1.9%
1998	0.07	0.03	2.3:1	267	1.71	1.8%	162	1.04	2.9%
1999	0.06	0.02	3.0:1	258	1.66	1.2%	178	1.14	1.8%
2000	0.05	0.02	2.5:1	268	1.72	1.2%	231	1.48	1.4%

DISCUSSION

For determining sampling efficiency, Method 3 is probably the most representative of the three methods presented here. The real value of presenting all three methods together is to demonstrate that despite the method used, sampling efficiency of stocked razorback sucker appears to be less than the 20% observed for the common fish species being collected in the majority of Miller and Lamarra's sampling. By extension, it can then be assumed that sampling efficiency for all rare fish species (razorback sucker, Colorado pikeminnow, and roundtail chub) via main channel electrofishing is low, probably less than 10% in most cases.

It is also apparent that sampling efficiency is very different for various size-classes of stocked razorback sucker. Larger fish are collected much more often (sampling efficiencies approaching 10%) via electrofishing than are small fish (sampling efficiencies less than 1%).